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Engelbart

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(45) **Date of Patent: Dec. 15, 2015**

(54) **METHOD FOR REMOTE REWORK IMAGING FOR PART INCONSISTENCIES**

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(73) Assignee: **THE BOEING COMPANY**, Chicago, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 220 days.

(21) Appl. No.: **13/868,724**

(22) Filed: **Apr. 23, 2013**

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/334,512, filed on Dec. 22, 2011, now Pat. No. 8,687,872, which is a continuation of application No. 12/103,178, filed on Apr. 15, 2008, now Pat. No. 8,094,921.

(51) **Int. Cl.**

G06K 9/00	(2006.01)
G06T 7/00	(2006.01)
G03B 29/00	(2006.01)

(52) **U.S. Cl.**
CPC ***G06T 7/0004*** (2013.01); ***G03B 29/00*** (2013.01)

(58) **Field of Classification Search**
CPC G01N 2021/8472; G03B 29/00; G06T 7/0004
See application file for complete search history.

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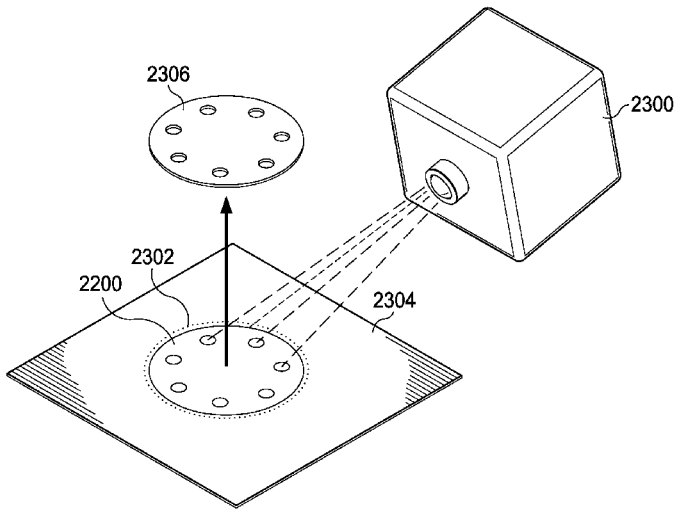
Primary Examiner — Kara E Geisel
(74) *Attorney, Agent, or Firm* — Yee & Associates, P.C.

(57) **ABSTRACT**

A method for reworking an inconsistency on a part. A location of the inconsistency is identified for the part in a model of the part. An image is generated for a rework for the part. The image is projected for the rework on the part based on the location identified for the inconsistency. The rework is performed for the inconsistency on the part using the image projected on the part.

18 Claims, 22 Drawing Sheets



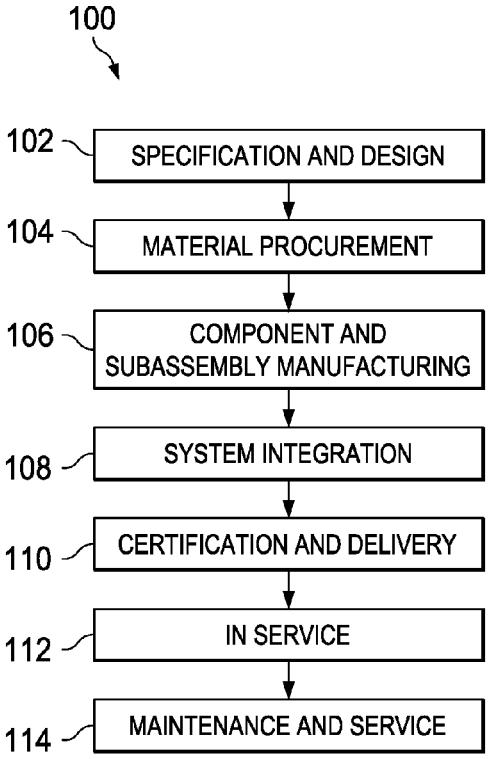

100
102
SPECIFICATION AND DESIGN
104
MATERIAL PROCUREMENT
106
COMPONENT AND SUBASSEMBLY MANUFACTURING
108
SYSTEM INTEGRATION
110
CERTIFICATION AND DELIVERY
112
IN SERVICE
114
MAINTENANCE AND SERVICE

FIG. 1

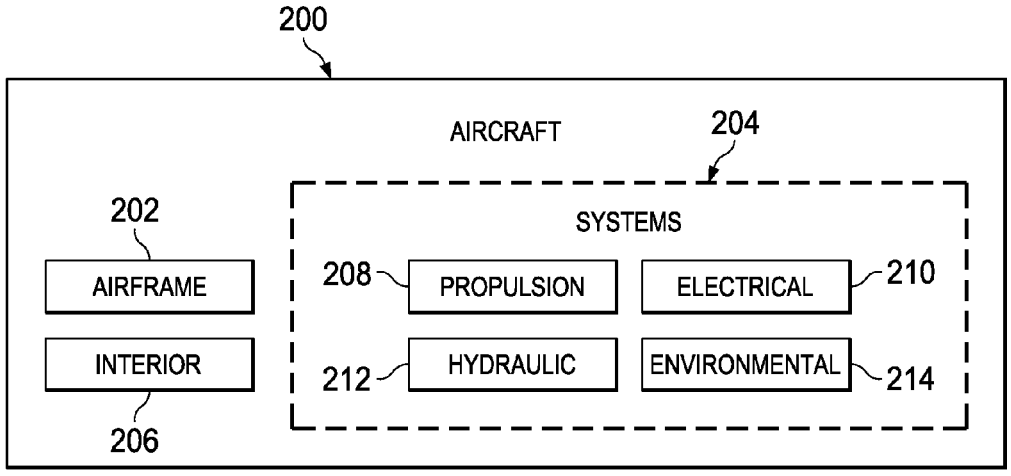

200
AIRCRAFT
204
202
SYSTEMS
AIRFRAME
208
PROPULSION
ELECTRICAL
210
INTERIOR
212
HYDRAULIC
ENVIRONMENTAL
214
206

FIG. 2

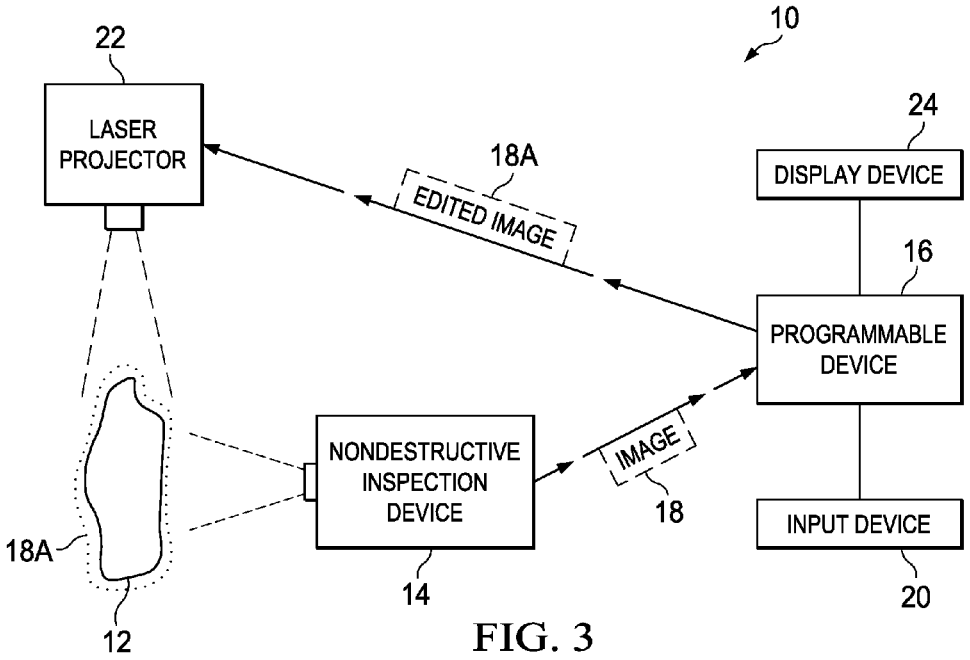

10
22
LASER PROJECTOR
18A
EDITED IMAGE
24
DISPLAY DEVICE
16
PROGRAMMABLE DEVICE
NONDESTRUCTIVE INSPECTION DEVICE
IMAGE
18
INPUT DEVICE
18A
12
14
20

FIG. 3

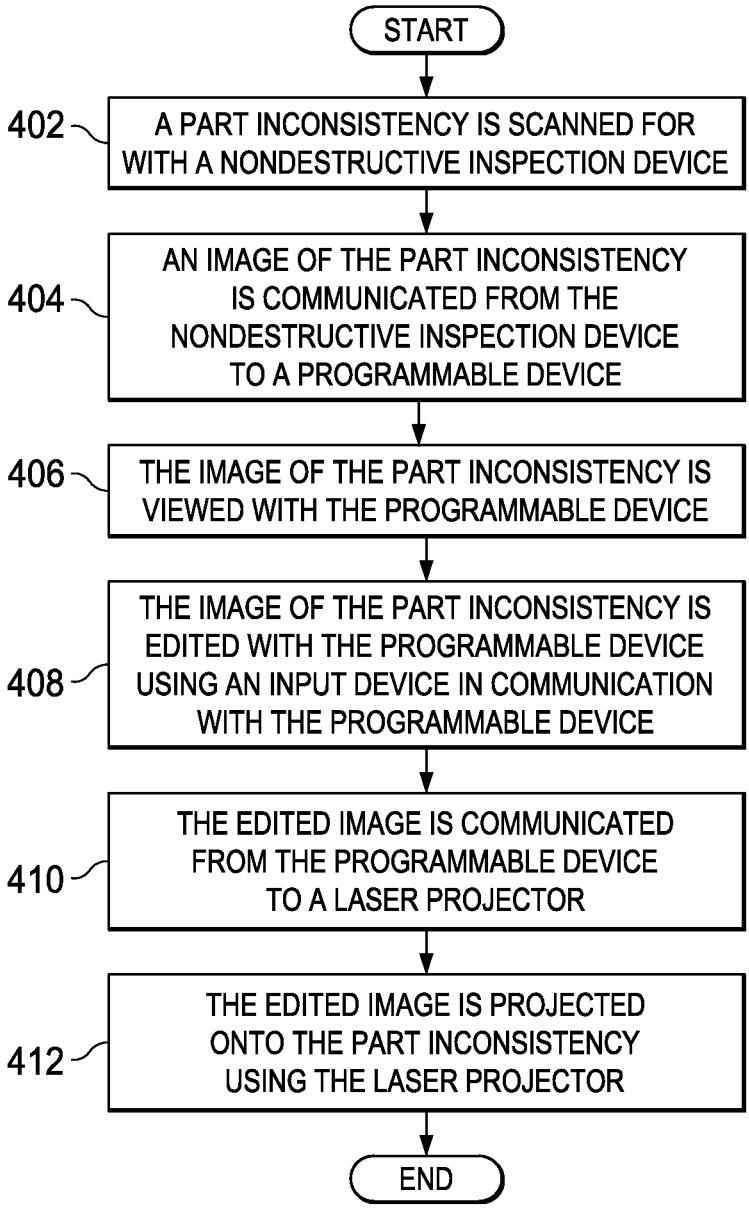

START
402
A PART INCONSISTENCY IS SCANNED FOR WITH A NONDESTRUCTIVE INSPECTION DEVICE
404
AN IMAGE OF THE PART INCONSISTENCY IS COMMUNICATED FROM THE NONDESTRUCTIVE INSPECTION DEVICE TO A PROGRAMMABLE DEVICE
406
THE IMAGE OF THE PART INCONSISTENCY IS VIEWED WITH THE PROGRAMMABLE DEVICE
408
THE IMAGE OF THE PART INCONSISTENCY IS EDITED WITH THE PROGRAMMABLE DEVICE USING AN INPUT DEVICE IN COMMUNICATION WITH THE PROGRAMMABLE DEVICE
410
THE EDITED IMAGE IS COMMUNICATED FROM THE PROGRAMMABLE DEVICE TO A LASER PROJECTOR
412
THE EDITED IMAGE IS PROJECTED ONTO THE PART INCONSISTENCY USING THE LASER PROJECTOR
END

FIG. 4

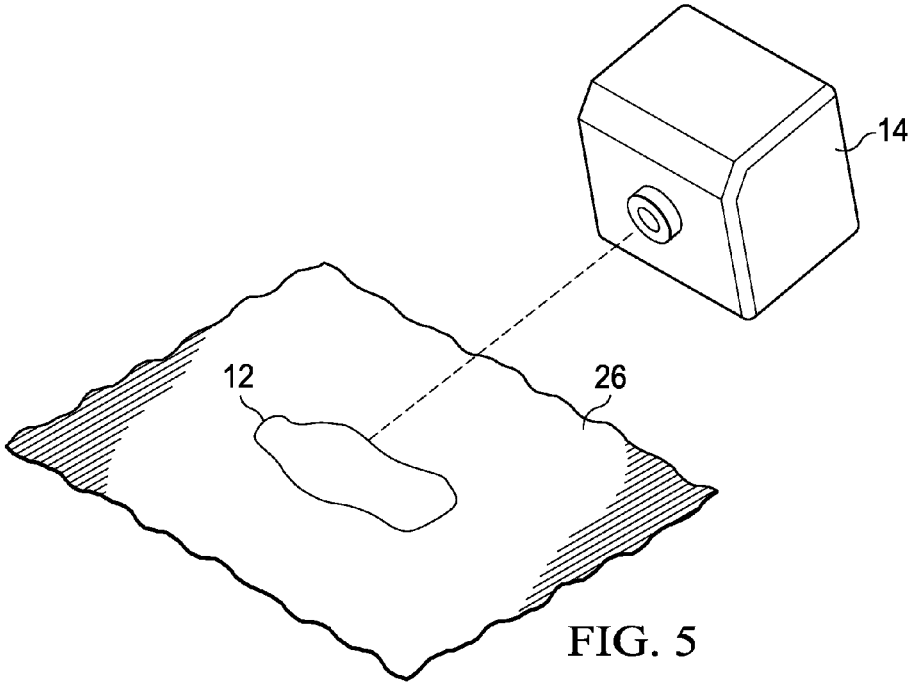
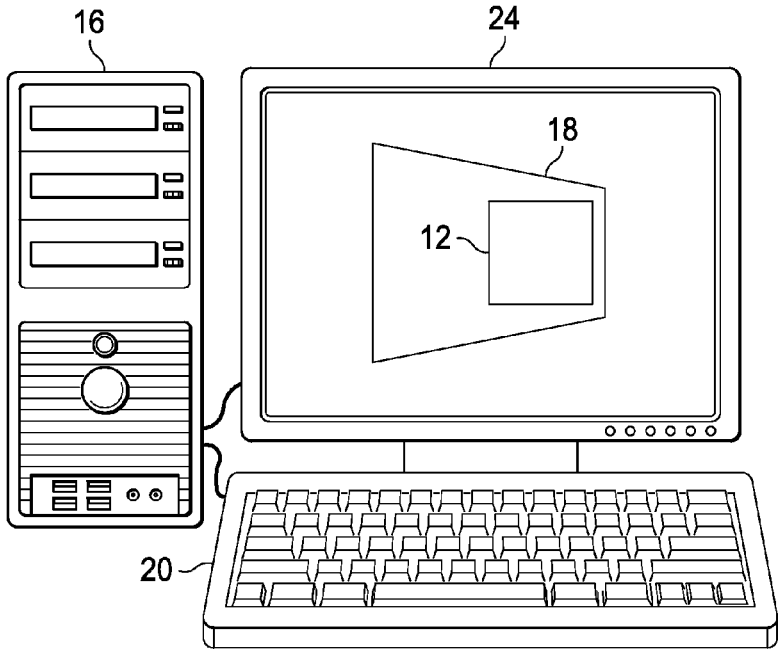


FIG. 5



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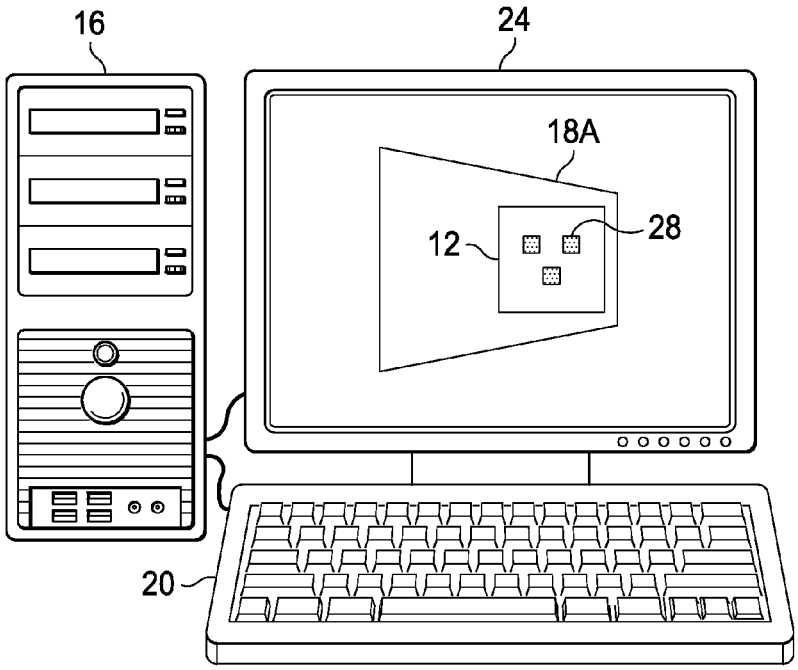


FIG. 7

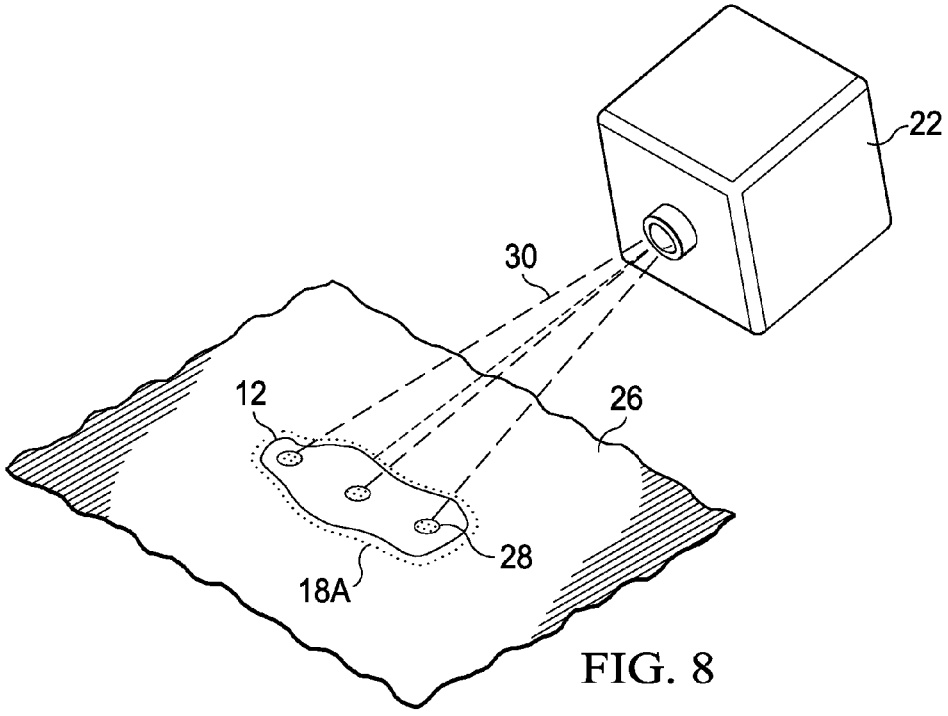


FIG. 8

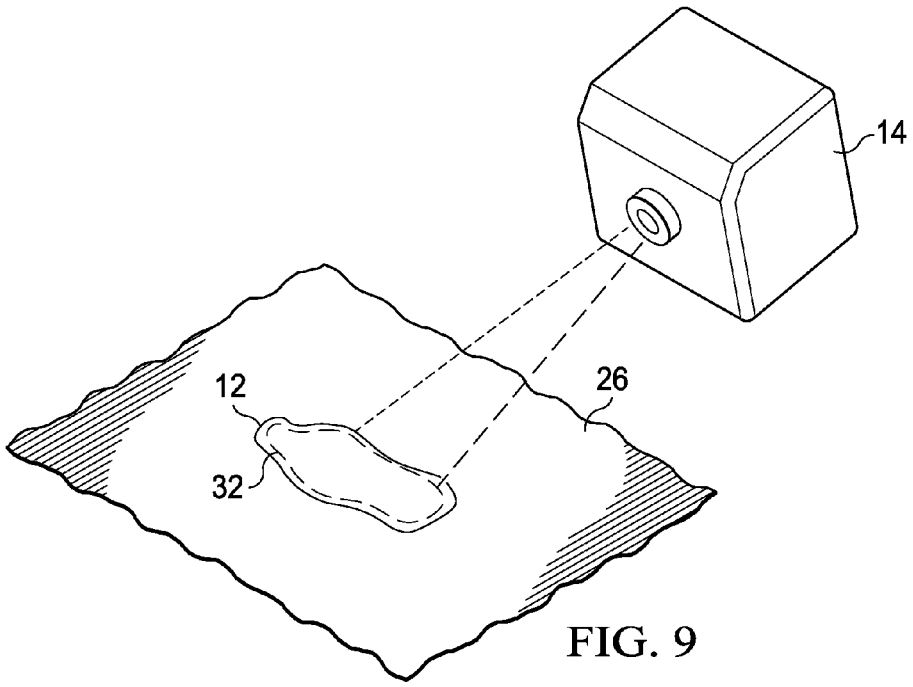


FIG. 9

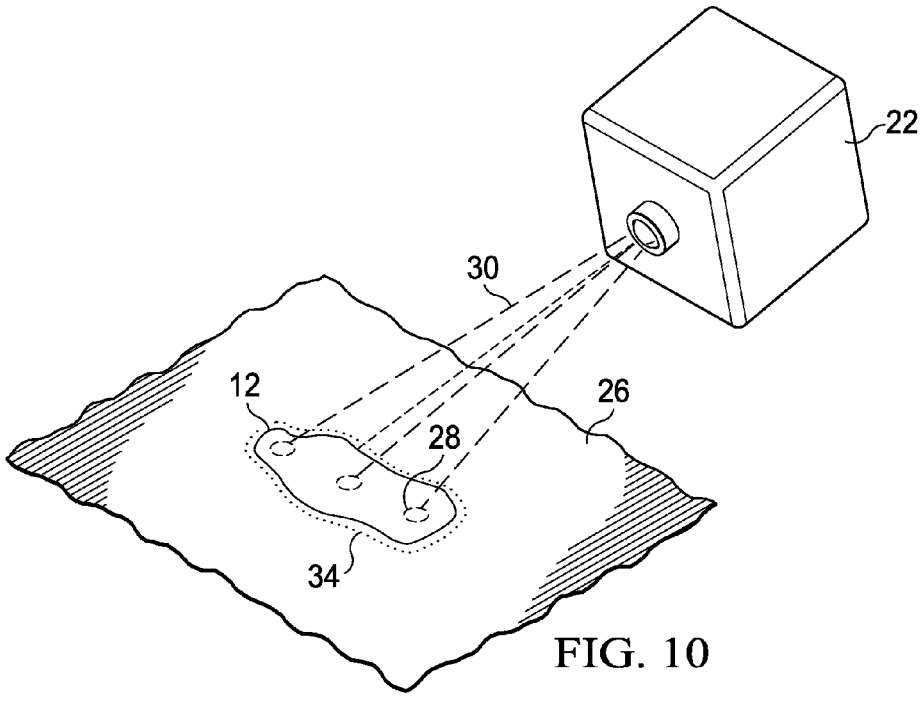


FIG. 10

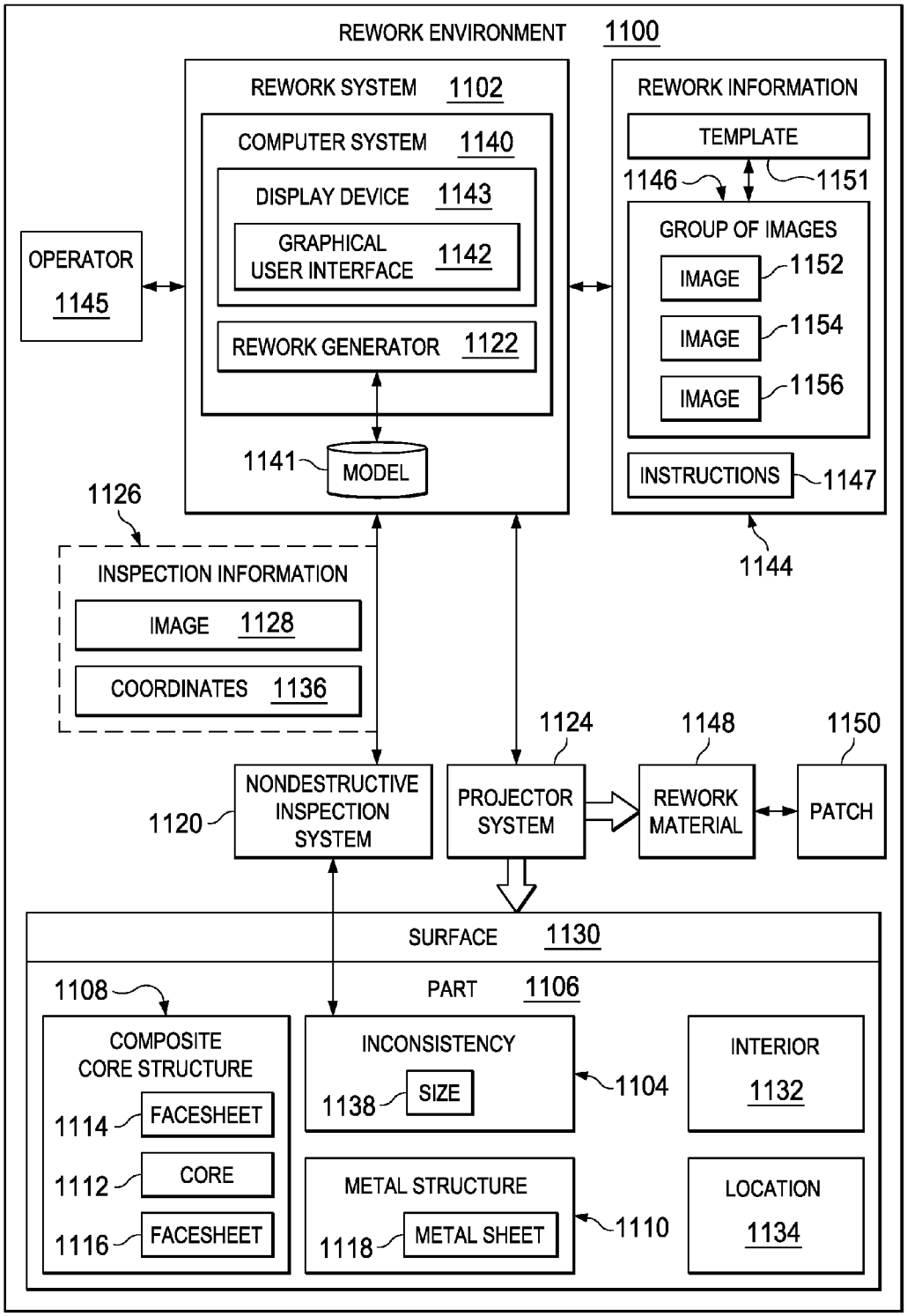

REWORK ENVIRONMENT 1100
REWORK SYSTEM 1102
COMPUTER SYSTEM 1140
DISPLAY DEVICE 1143
GRAPHICAL USER INTERFACE 1142
REWORK GENERATOR 1122
1141
MODEL
OPERATOR 1145
REWORK INFORMATION
TEMPLATE
1146
1151
GROUP OF IMAGES
IMAGE 1152
IMAGE 1154
IMAGE 1156
INSTRUCTIONS 1147
1144
1126
INSPECTION INFORMATION
IMAGE 1128
COORDINATES 1136
1124
1148
1150
1120
NONDESTRUCTIVE INSPECTION SYSTEM
PROJECTOR SYSTEM
REWORK MATERIAL
PATCH
SURFACE 1130
1108
PART 1106
COMPOSITE CORE STRUCTURE
1114
FACESHEET
1112
CORE
1116
FACESHEET
INCONSISTENCY
1138
SIZE
1104
METAL STRUCTURE
1118
METAL SHEET
1110
INTERIOR 1132
LOCATION 1134

FIG. 11

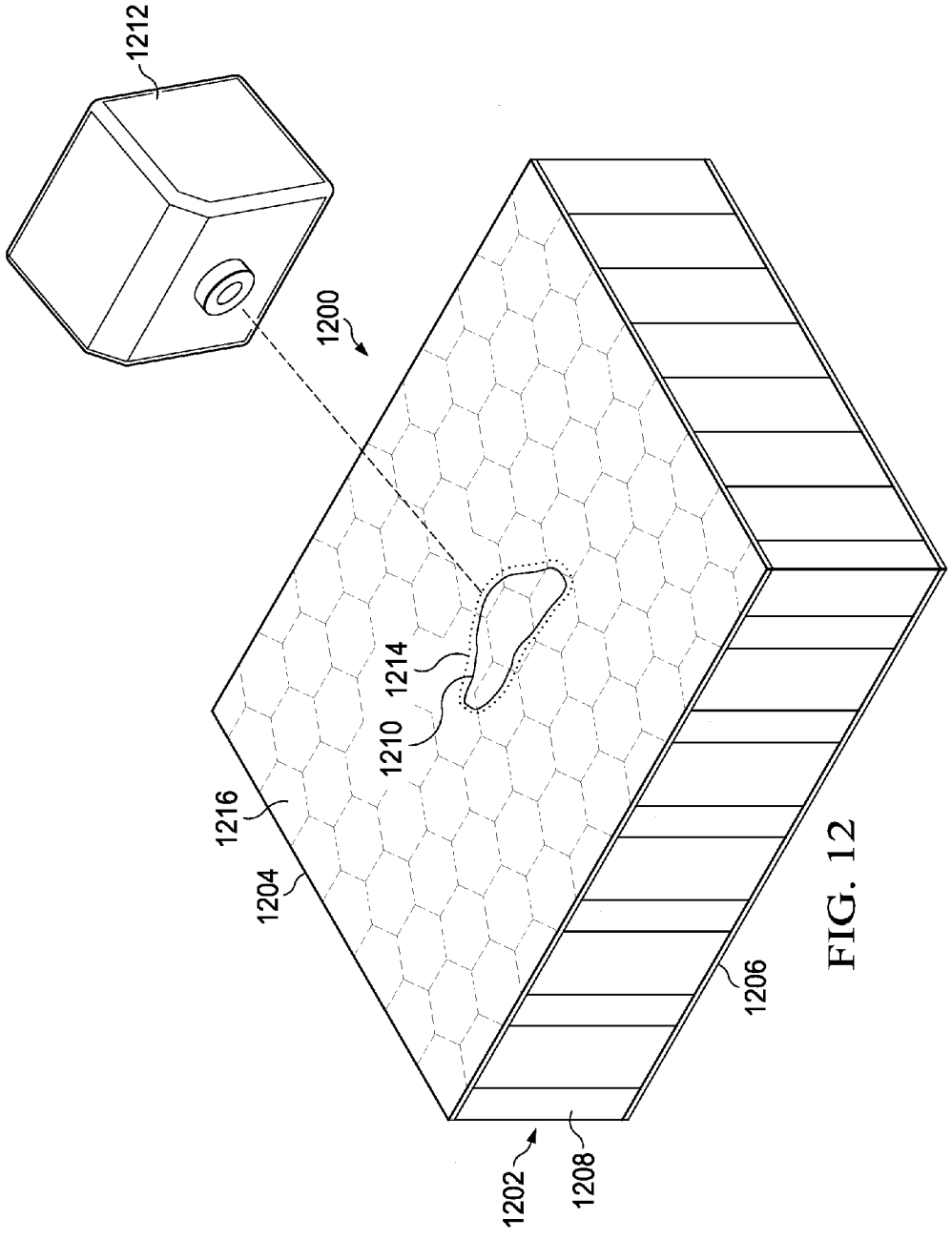


FIG. 12

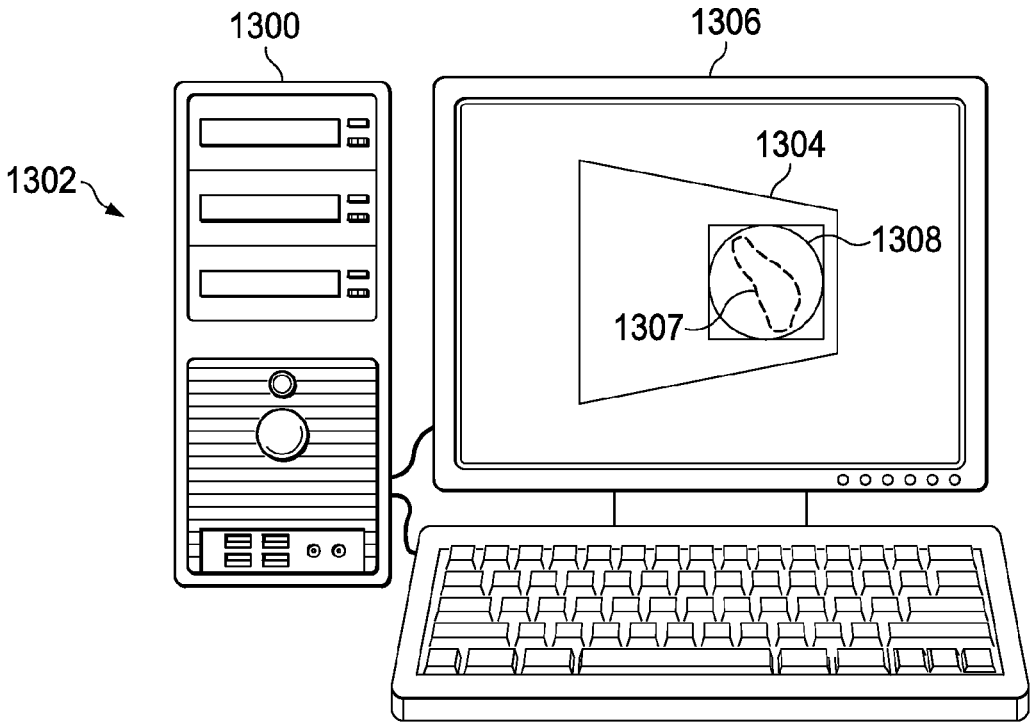
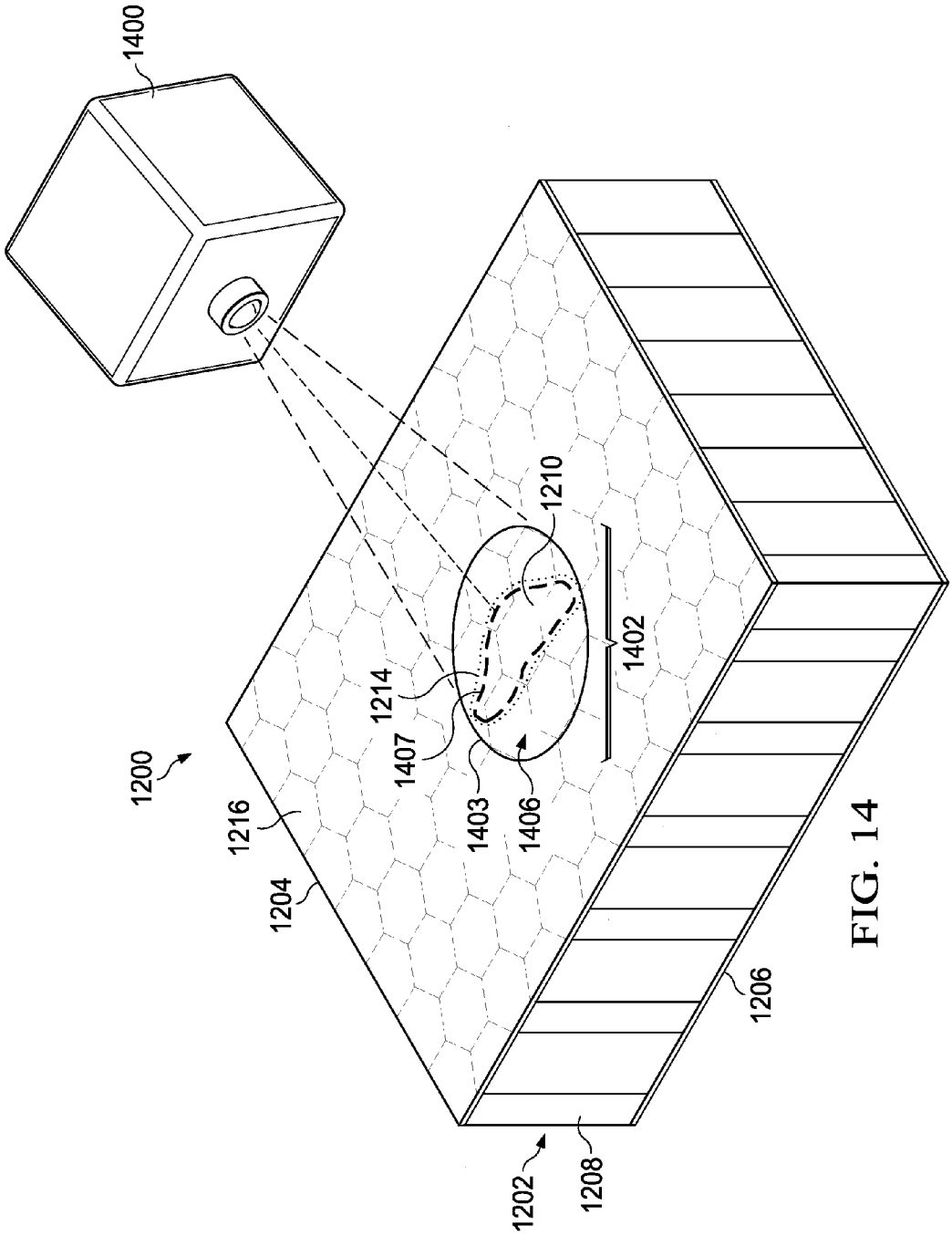


FIG. 13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1402
1407
1403
1406
1200
1216
1204
1206
1202
1208

FIG. 14

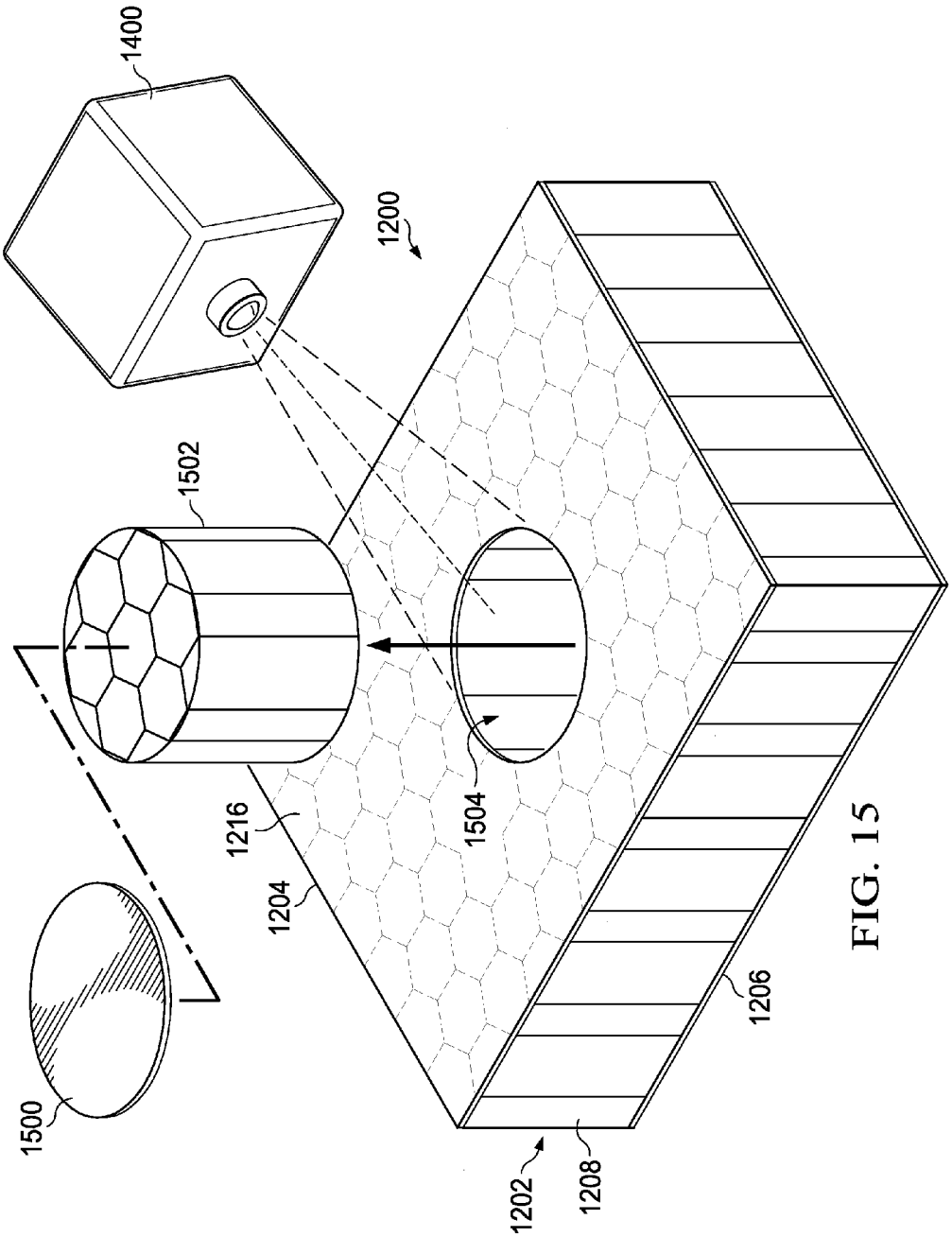


FIG. 15

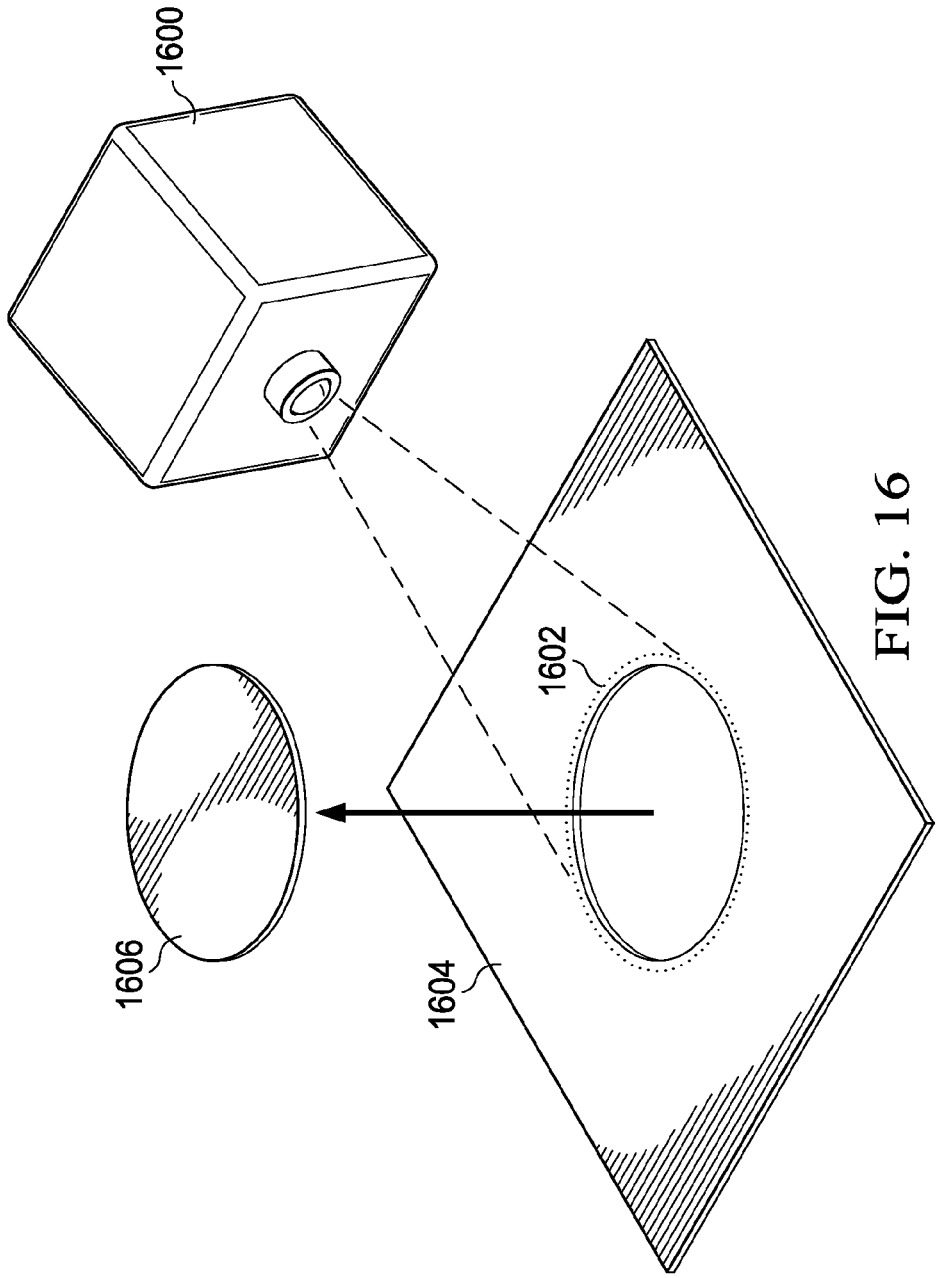


FIG. 16

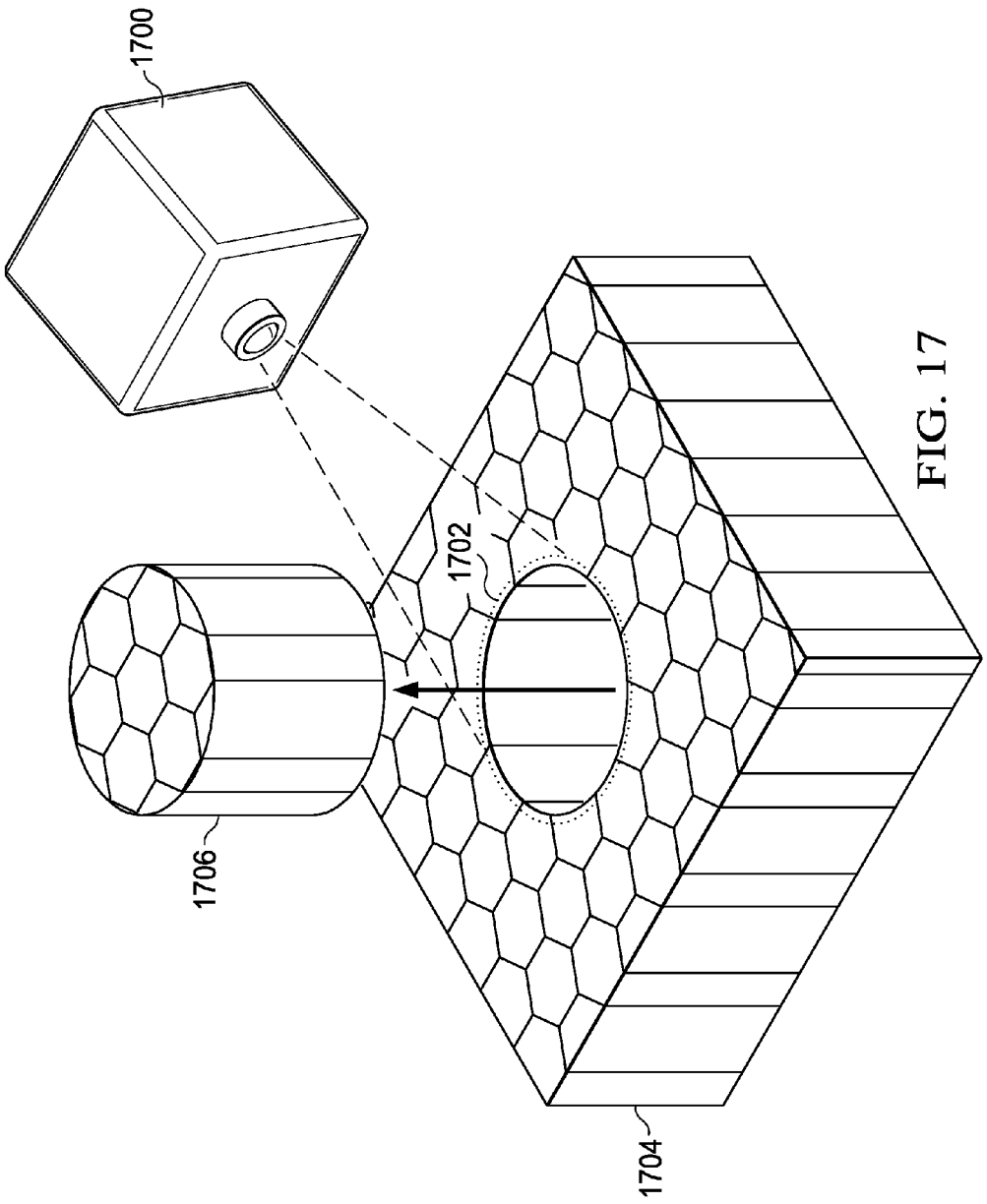


FIG. 17

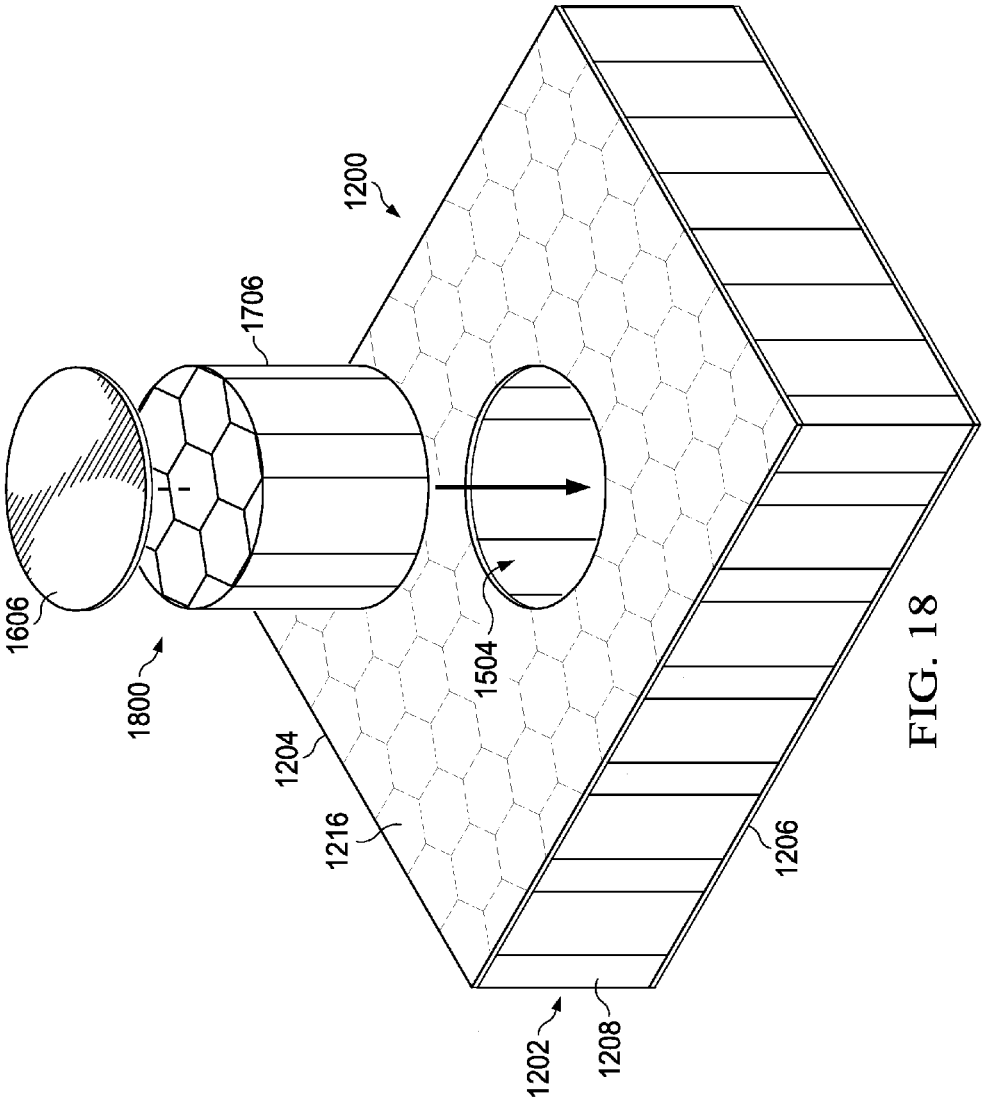
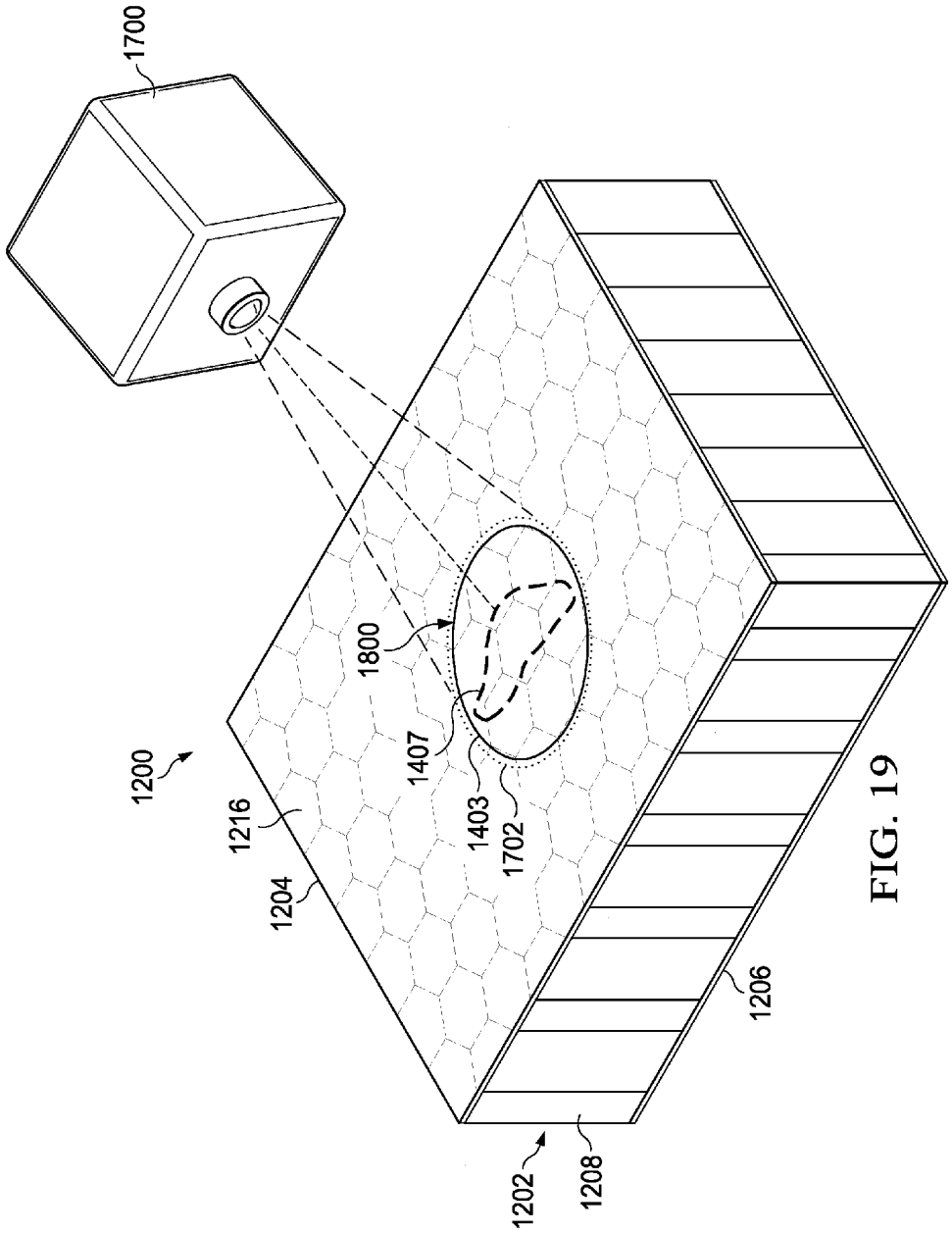


FIG. 18



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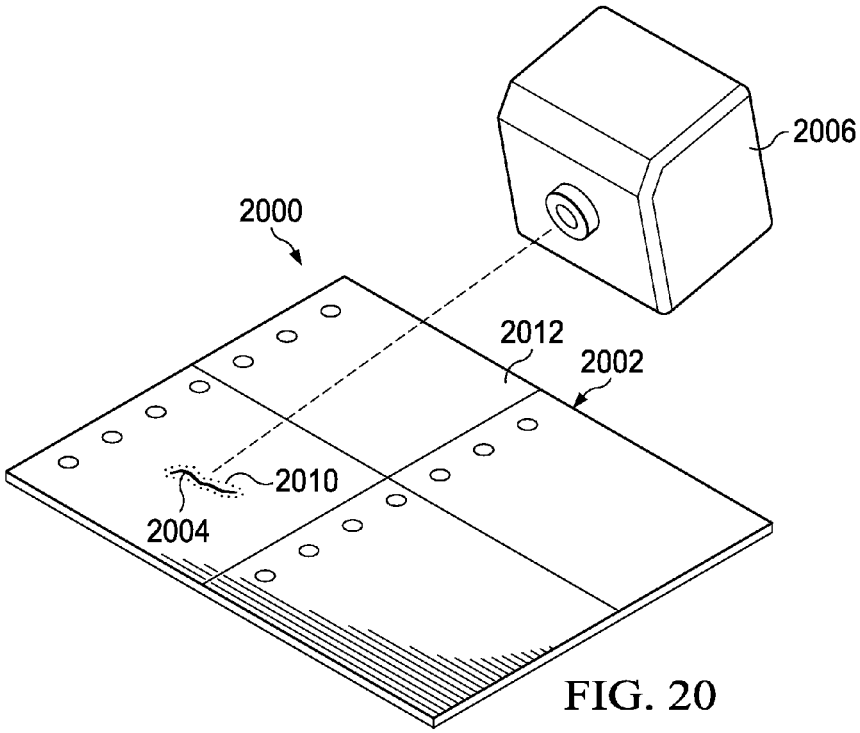
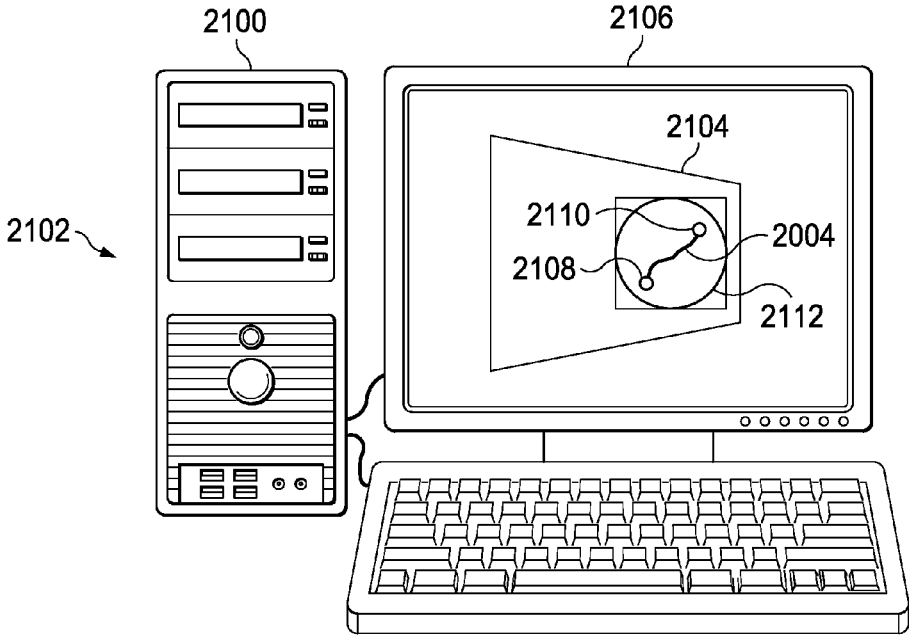

2006
2000
2012
2002
2010
2004

FIG. 20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2106
2104
2102
2110
2004
2108
2112

FIG. 21

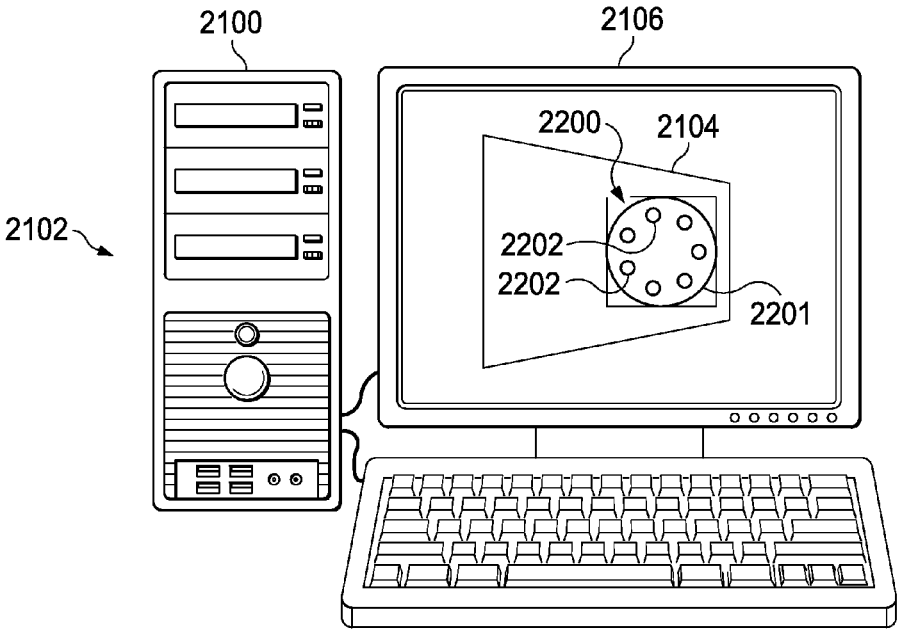
2100
2106
2200
2104
2102
2202
2202
2201

FIG. 22

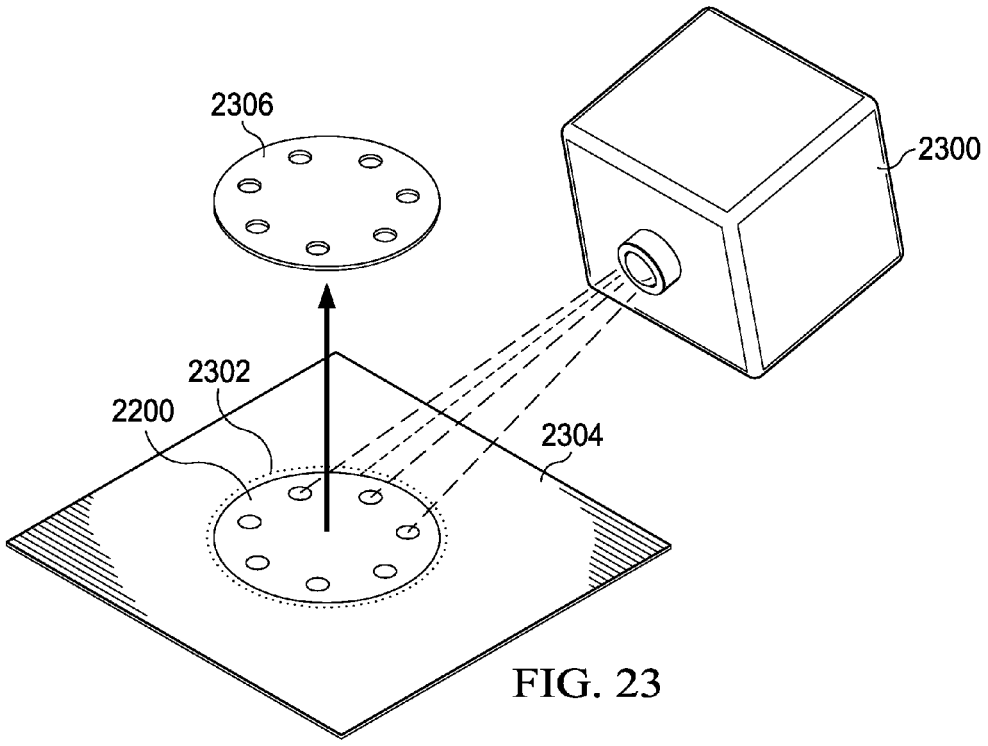
2306
2300
2302
2200
2304

FIG. 23

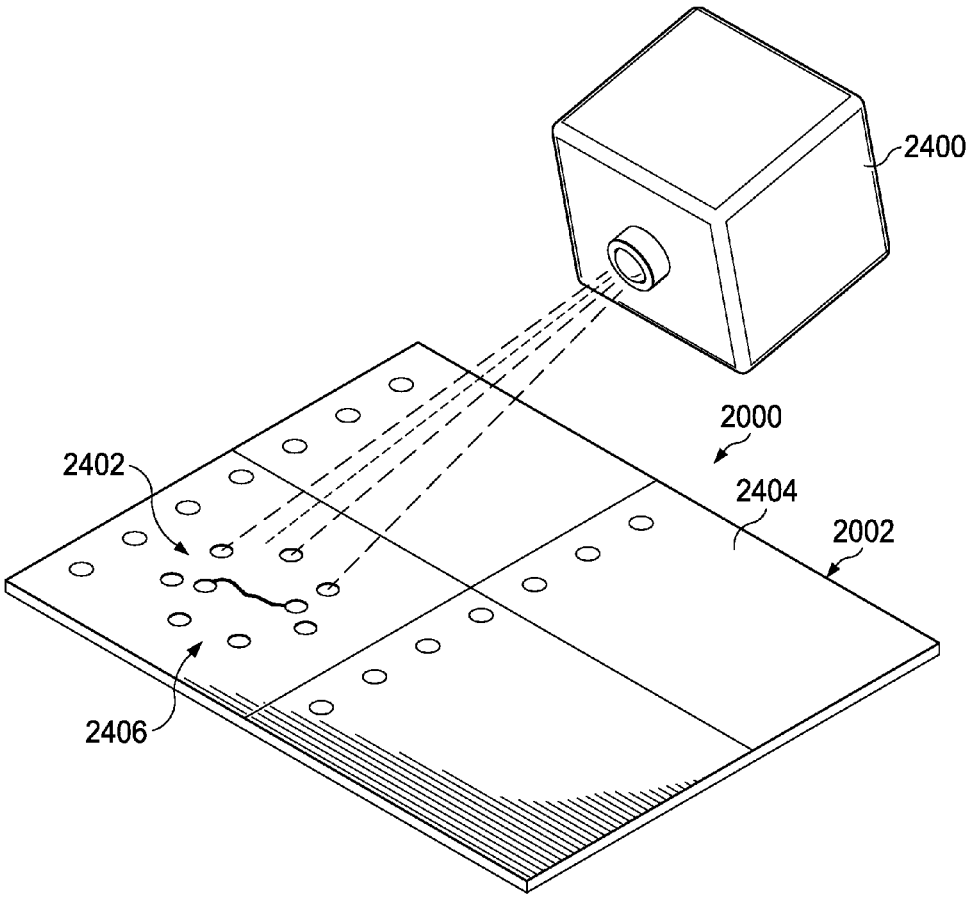

FIG. 24

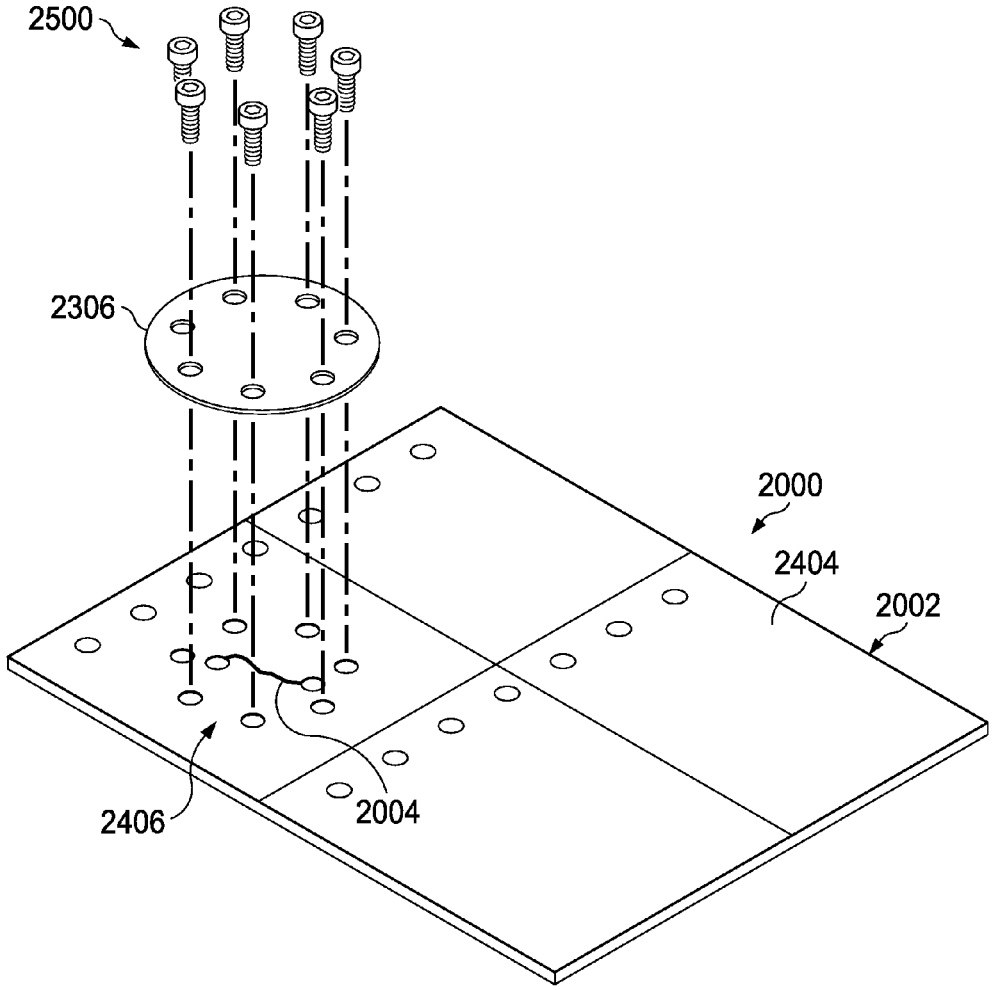

FIG. 25

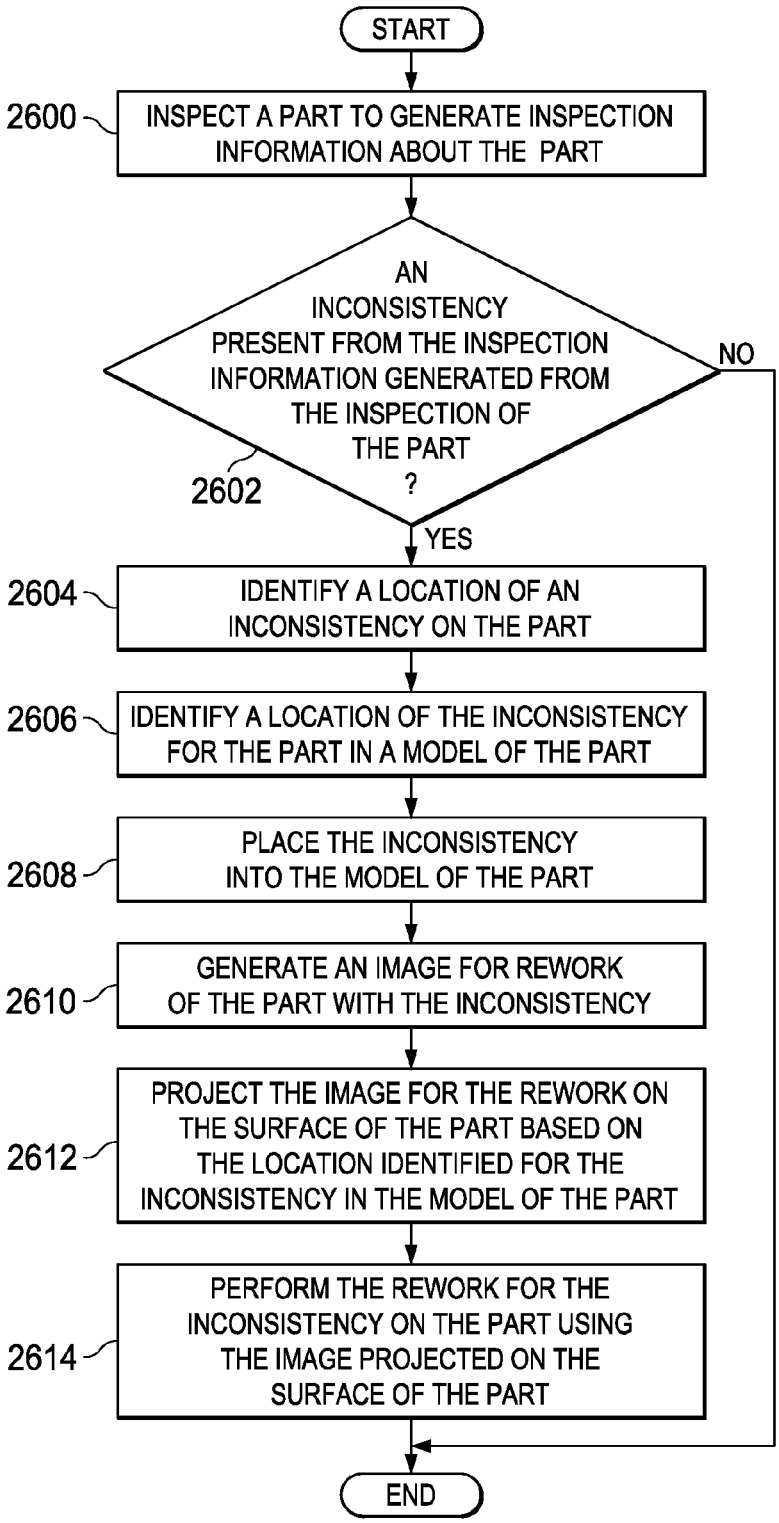
START
2600
INSPECT A PART TO GENERATE INSPECTION INFORMATION ABOUT THE PART
AN INCONSISTENCY PRESENT FROM THE INSPECTION INFORMATION GENERATED FROM THE INSPECTION OF THE PART ?
2602
NO
YES
2604
IDENTIFY A LOCATION OF AN INCONSISTENCY ON THE PART
2606
IDENTIFY A LOCATION OF THE INCONSISTENCY FOR THE PART IN A MODEL OF THE PART
2608
PLACE THE INCONSISTENCY INTO THE MODEL OF THE PART
2610
GENERATE AN IMAGE FOR REWORK OF THE PART WITH THE INCONSISTENCY
2612
PROJECT THE IMAGE FOR THE REWORK ON THE SURFACE OF THE PART BASED ON THE LOCATION IDENTIFIED FOR THE INCONSISTENCY IN THE MODEL OF THE PART
2614
PERFORM THE REWORK FOR THE INCONSISTENCY ON THE PART USING THE IMAGE PROJECTED ON THE SURFACE OF THE PART
END

FIG. 26

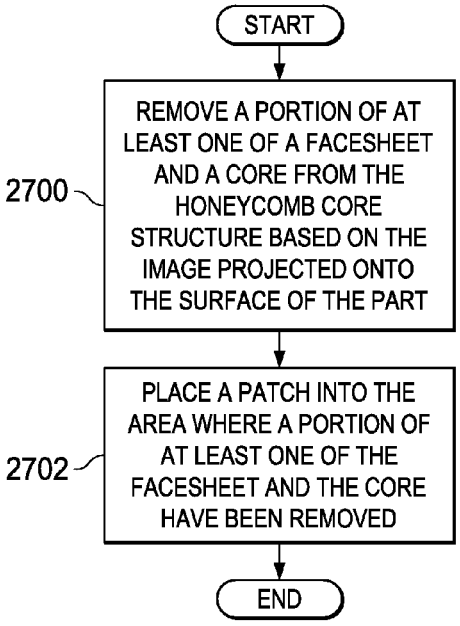

FIG. 27

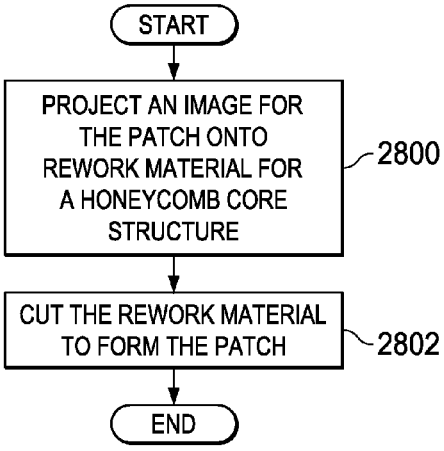

FIG. 28

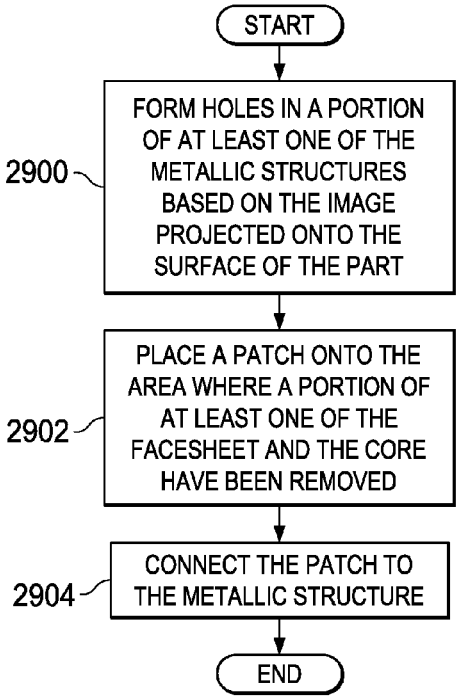

FIG. 29

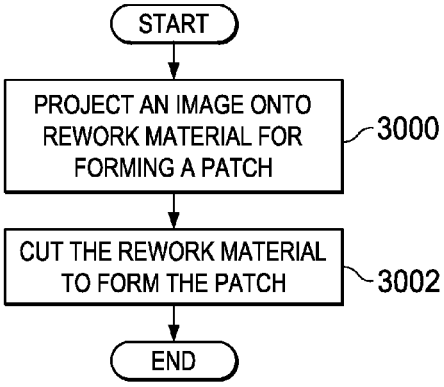

FIG. 30

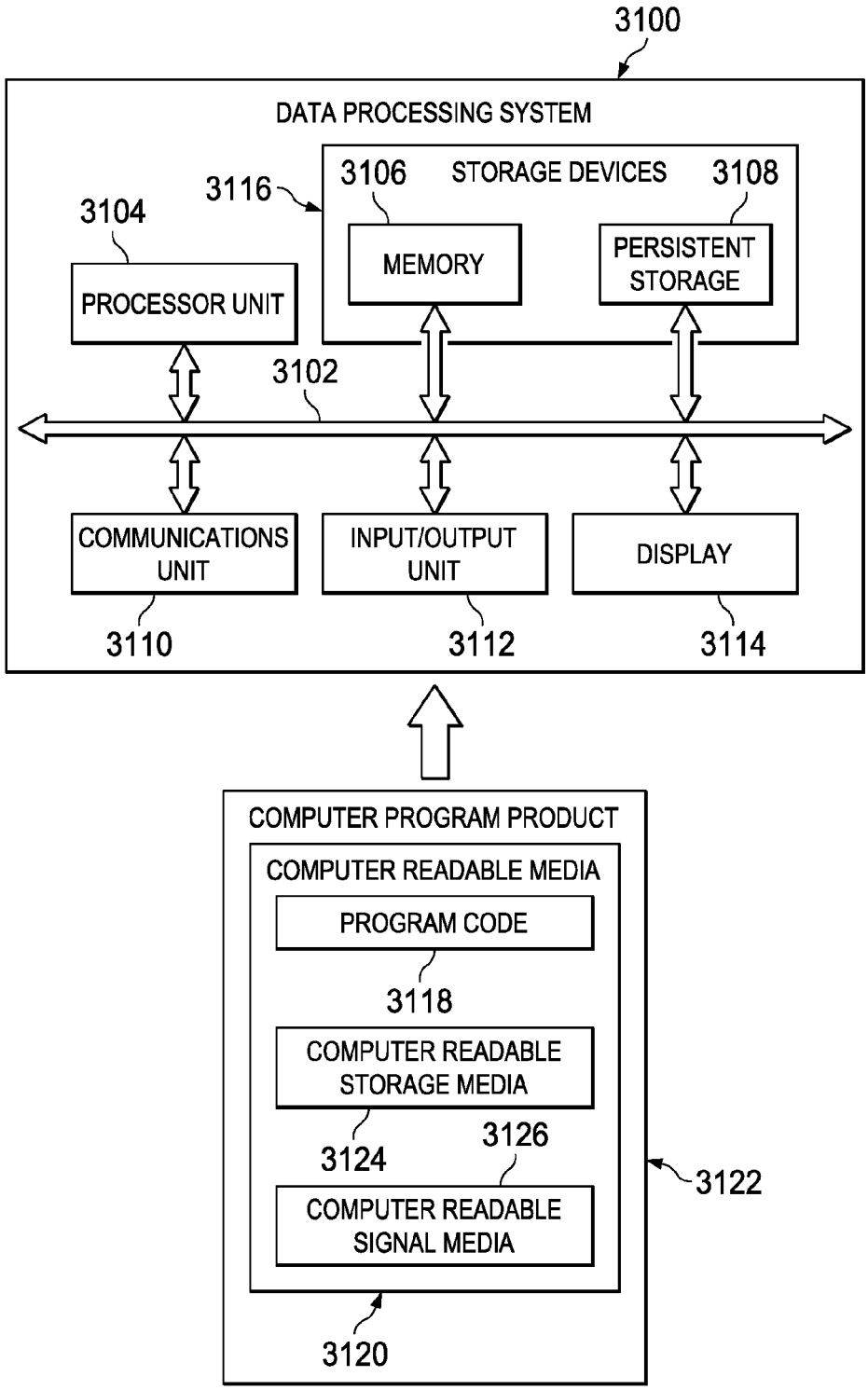
3100
DATA PROCESSING SYSTEM
3116
3106
STORAGE DEVICES
3108
3104
MEMORY
PERSISTENT STORAGE
PROCESSOR UNIT
3102
COMMUNICATIONS UNIT
INPUT/OUTPUT UNIT
DISPLAY
3110
3112
3114
COMPUTER PROGRAM PRODUCT
COMPUTER READABLE MEDIA
PROGRAM CODE
3118
COMPUTER READABLE STORAGE MEDIA
3124
3126
COMPUTER READABLE SIGNAL MEDIA
3122
3120

FIG. 31

METHOD FOR REMOTE REWORK IMAGING FOR PART INCONSISTENCIES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of patent application U.S. Ser. No. 13/334,512, filed Dec. 22, 2011, entitled "Method and System for Remote Rework Imaging for Part Inconsistencies,", which is a continuation application of patent application U.S. Ser. No. 12/103,178, filed Apr. 15, 2008, entitled "Method and System for Remote Rework Imaging for Part Inconsistencies,", each of which are incorporated herein by reference.

BACKGROUND INFORMATION

1. Field

The present disclosure is generally related to a method and system for remote rework imaging for part inconsistencies. The disclosure has particular utility in connection with rework of composite parts and structures found in vehicles, including, but not limited to, aircraft, autos, trucks, buses, trains, ships or satellites and will be described in connection with such utility, although other utilities are contemplated.

2. Background

A wide variety of nondestructive evaluation methods (nondestructive inspection), such as ultrasonics, eddy current, x-ray, magnetic resonance, and microwave, have been utilized to inspect post-manufacture parts, which may comprise metal and/or composite and/or ceramic parts or other types of parts. Both water based, gantry style systems, and portable instruments have been utilized to conduct this evaluation. Some of the prior art methods conduct scans of the post-manufacture parts, and then print out full-scale paper plots of the parts or the inconsistency areas, which are then aligned over the parts in order to rework the inconsistencies. Sometimes, the inconsistency areas of the printed plot are cut out in order to trace the inconsistencies on the parts. Other methods overlay the printed plot with a transparent Mylar sheet in order to trace the outlines of any inconsistencies on the Mylar, which is then laid over the part in order to trace the inconsistencies onto the part for rework of the inconsistencies. Mylar is a polyethylene terephthalate polyester film. One or more of these methods may be costly, may take substantial time, may be difficult to administer, may be inefficient, may be inconsistent, may lead to error, may not allow for repeatability, and/or may experience other types of problems.

Further, for the rework to be made, one or more engineers frequently need to review the plotted inconsistency and develop a plan to rework, remove, or diminish the inconsistencies. Once the plan is developed, the engineer(s) join one or more technicians and explain to the technicians how the inconsistencies should be reworked. This method of resolving inconsistencies requires engineers to be on-site in any manufacturing site at which rework of inconsistencies may occur. Sometimes, the engineer will plot the rework (e.g., injection hole locations) on the same paper or other surface on which the inconsistency is plotted. The technician will attempt to use that plotted rework to carry out the rework. However, if the plot is not properly aligned on the part, the inconsistency will be incorrectly reworked.

Therefore, it would be desirable to have a method and apparatus that takes into account at least some of the issues discussed above, as well as other possible issues.

SUMMARY

In one illustrative embodiment, a method for reworking an inconsistency on a part is present. A location of the inconsistency is identified for the part in a model of the part. An image is generated for a rework for the part. The image is projected for the rework on the part based on the location identified for the inconsistency. The rework is performed for the inconsistency on the part using the image projected on the part.

In another illustrative embodiment, an apparatus comprises a rework generator configured to identify a location of an inconsistency for a part in a model of the part. The rework generator is further configured to generate an image for a rework for the part. The rework generator is still further configured to project the image for the rework on the part based on the location identified for the inconsistency. The rework generator is further configured to perform the rework for the inconsistency on the part using the image projected on the part.

Other systems, methods, features, and advantages of the present disclosure will be or become apparent upon examination of the following drawings and detailed description. It is intended that all such additional systems, methods, features, and advantages be included within this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

Many aspects of the present disclosure can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present disclosure. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

FIG. **1** is an illustration of an aircraft manufacturing and service method in the form of a block diagram in accordance with an illustrative embodiment;

FIG. **2** is an illustration of an aircraft in the form of a block diagram in which an illustrative embodiment may be implemented;

FIG. **3** is an illustration of a system for remote rework imaging for a part inconsistency in accordance with an illustrative embodiment;

FIG. **4** is an illustration of a flowchart illustrating a method of remote rework imaging for a part inconsistency in accordance with an illustrative embodiment;

FIG. **5** is an illustration of the projection of data from a scan of a part inconsistency being scanned with a nondestructive inspection device in accordance with an illustrative embodiment;

FIG. **6** is an illustration of an image of a part inconsistency viewed using a programmable device in accordance with an illustrative embodiment;

FIG. **7** is an illustration of an edited image of a part inconsistency viewed using a programmable device in accordance with an illustrative embodiment;

FIG. **8** is an illustration of an edited image projected onto a part fragment with a laser projector in accordance with an illustrative embodiment;

FIG. **9** is an illustration of the projection of data from a rescan of a part inconsistency being rescanned with a nondestructive inspection device in accordance with an illustrative embodiment;

FIG. **10** is an illustration of a second edited image projected onto the part fragment with the laser projector, following the second scan, in accordance with an illustrative embodiment;

FIG. **11** is an illustration of a rework environment in the form of a block diagram in accordance with an illustrative embodiment;

FIG. **12** is an illustration of an inspection of a part with a composite honeycomb core structure in accordance with an illustrative embodiment;

FIG. **13** is an illustration of an inconsistency placed into a model of a part with a composite honeycomb core structure in accordance with an illustrative embodiment;

FIG. **14** is an illustration of a projection of an image for reworking a composite honeycomb core structure in accordance with an illustrative embodiment;

FIG. **15** is an illustration of a removal of a portion of a composite honeycomb core structure in accordance with an illustrative embodiment;

FIG. **16** is an illustration of the formation of a portion of a patch in accordance with an illustrative embodiment;

FIG. **17** is another illustration of the formation of a portion of a patch in accordance with an illustrative embodiment;

FIG. **18** is an illustration of reworking a part with a honeycomb core structure in accordance with an illustrative embodiment;

FIG. **19** is an illustration of a verification of rework on a honeycomb core structure in accordance with an illustrative embodiment;

FIG. **20** is an illustration of inspection of a metal structure in accordance with an illustrative embodiment;

FIG. **21** is an illustration of an inconsistency placed into a model of a part in accordance with an illustrative embodiment;

FIG. **22** is an illustration of the creation of rework information in accordance with an illustrative embodiment;

FIG. **23** is an illustration of the formation of a patch in accordance with an illustrative embodiment;

FIG. **24** is an illustration of reworking a metal structure in accordance with an illustrative embodiment;

FIG. **25** is another illustration of reworking a metal structure in accordance with an illustrative embodiment;

FIG. **26** is an illustration of a flowchart of a process for reworking an inconsistency on a part in accordance with an illustrative embodiment;

FIG. **27** is an illustration of a flowchart of a process for performing rework on a composite core structure in accordance with an illustrative embodiment;

FIG. **28** is an illustration of a flowchart of a process for forming a patch for reworking a honeycomb core structure in accordance with an illustrative embodiment;

FIG. **29** is an illustration of a flowchart of a process for performing rework on a metallic structure in accordance with an illustrative embodiment;

FIG. **30** is an illustration of a flowchart of a process for creating a patch for a metallic structure in accordance with an illustrative embodiment; and

FIG. **31** is an illustration of a block diagram of a data processing system in accordance with an illustrative embodiment.

DETAILED DESCRIPTION

Referring more particularly to the drawings, embodiments of the disclosure may be described in the context of aircraft manufacturing and service method **100** as shown in FIG. **1** and aircraft **200** as shown in FIG. **2**. Turning first to FIG. **1**, an illustration of an aircraft manufacturing and service method is depicted in the form of a block diagram in accordance with an illustrative embodiment. During pre-production, aircraft manufacturing and service method **100** may include specification and design **102** of aircraft **200** in FIG. **2** and material procurement **104**.

During production, component and subassembly manufacturing **106** and system integration **108** of aircraft **200** in FIG. **2** takes place. Thereafter, aircraft **200** in FIG. **2** may go through certification and delivery **110** in order to be placed in service **112**. While in service **112** by a customer, aircraft **200** in FIG. **2** is scheduled for routine maintenance and service **114**, which may include modification, reconfiguration, refurbishment, and other maintenance or service.

Each of the processes of aircraft manufacturing and service method **100** may be performed or carried out by a system integrator, a third party, and/or an operator. In these examples, the operator may be a customer. For the purposes of this description, a system integrator may include, without limitation, any number of aircraft manufacturers and major-system subcontractors; a third party may include, without limitation, any number of vendors, subcontractors, and suppliers; and an operator may be an airline, a leasing company, a military entity, a service organization, and so on.

With reference now to FIG. **2**, an illustration of an aircraft is depicted in the form of a block diagram in which an illustrative embodiment may be implemented. In this example, aircraft **200** is produced by aircraft manufacturing and service method **100** in FIG. **1** and may include airframe **202** with systems **204** and interior **206**. Examples of systems **204** include one or more of propulsion system **208**, electrical system **210**, hydraulic system **212**, and environmental system **214**. Any number of other systems may be included. Although an aerospace example is shown, different illustrative embodiments may be applied to other industries, such as the automotive industry.

Apparatuses and methods embodied herein may be employed during at least one of the stages of aircraft manufacturing and service method **100** in FIG. **1**. As used herein, the phrase "at least one of," when used with a list of items, means that different combinations of one or more of the listed items may be used and only one of each item in the list may be needed. For example, "at least one of item A, item B, and item C" may include, for example, without limitation, item A or item A and item B. This example also may include item A, item B, and item C or item B and item C. The item may be a particular object, thing, or a category. In other words, at least one of means any combination of items and number of items may be used from the list but not all of the items in the list are required.

In one illustrative example, components or subassemblies produced in component and subassembly manufacturing **106** in FIG. **1** may be fabricated or manufactured in a manner similar to components or subassemblies produced while aircraft **200** is in service **112** in FIG. **1**. As yet another example, a number of apparatus embodiments, method embodiments, or a combination thereof may be utilized during production stages, such as component and subassembly manufacturing **106** and system integration **108** in FIG. **1**. A number, when referring to items, means one or more items. For example, a number of apparatus embodiments is one or more apparatus embodiments. A number of apparatus embodiments, method embodiments, or a combination thereof may be utilized while aircraft **200** is in service **112** and/or during maintenance and service **114** in FIG. **1**. The use of a number of the different illustrative embodiments may substantially expedite the assembly of and/or reduce the cost of aircraft **200**.

FIG. **3**, an illustration of system **10** for remote rework imaging for part inconsistency **12**, is depicted in accordance with an illustrative embodiment. "Inconsistency," as used in the appropriate context throughout this disclosure, refers to the difference and/or out-of-tolerance between one or more measured characteristics of a part or structure under test and/

or examination (and potentially effected by exposure to factor (s) including, but not limited to, thermal load(s), moisture, galvanic action, structural load(s), lightning, or electrical arcing) with expected values for the same characteristics of an analogous structure within tolerance and/or unaffected by exposure to those factors. "Rework," as used in the appropriate context throughout this disclosure, refers to changing and/or adjusting an out-of-tolerance condition to a condition within tolerance.

System **10** contains nondestructive inspection device **14**. Programmable device **16** for viewing and editing images is in communication with nondestructive inspection device **14** as described below. Image **18** of the part inconsistency **12** is communicated from nondestructive inspection device **14** and edited on programmable device **16**. Input device **20** is in communication with programmable device **16**. Input device **20** is useful for editing image **18** on programmable device **16**. Laser projector **22** is in communication with programmable device **16**. Laser projector **22** is local to the part or structure under tests. Edited image **18**A is projected from laser projector **22** onto part inconsistency **12**.

Nondestructive inspection device **14** could be any of a number of known inspection devices, including ultrasonics, eddy current, x-ray, magnetic resonance, and microwave. Yet other known nondestructive inspection devices also advantageously may be used. The requirements on nondestructive inspection device **14** are that it is capable of inspecting the condition of a part or structure and producing image **18** of the same. Nondestructive inspection device **14** is in communication with programmable device **16**. The communication is such that image **18** is communicated from nondestructive inspection device **14** to programmable device **16**. Image **18** may be communicated by wireless or wired connection, through a network, through a portable disk or stick or other memory devices that may be used to transport an image file, or any combination of the above.

Programmable device **16** may be a personal computer, laptop, personal digital assistant, or any other electronic device that can be used to view and edit image **18** received from nondestructive inspection device **14**. Programmable device **16** may include or be attached to input device **20**. Input device **20** may include a mouse, digital pen, wand, touch screen, keyboard, or any other electronic device compatible with programmable device **16** that may be useful for editing image **18** received from nondestructive inspection device **14**. Programmable device **16** may be attached to, integral with, or at least in communication with display device **24** for viewing image **18**. A purpose of editing image **18** may include providing rework instructions and/or details for reworking part inconsistency **12**. For example, an engineer may receive image **18** on programmable device **16** and use input device **20** to edit image **18** to detail the location of one or more injection holes for injecting resin into part inconsistency **12**. A technician or laborer may use edited image **18**A to rework part inconsistency **12**.

Laser projector **22** is in communication with programmable device **16**. The communication must be such that edited image **18**A is communicable from programmable device **16** to laser projector **22**. Edited image **18**A may be communicated by wireless or wired connection, through a network, through a portable disk or stick or other memory device that may be used to transport an image file, or any combination of the above. Laser projector **22** may then be used to project edited image **18**A onto part inconsistency **12**. A technician or laborer may use edited image **18**A to rework part inconsistency **12**. The engineer responsible for detailing edited image **18**A may be located remotely relative to part inconsistency **12** while still directing rework of the same.

FIG. **4**, an illustration of a flowchart illustrating a method of remote rework imaging for part inconsistency **12**, is depicted in accordance with an illustrative embodiment. It should be noted that any process descriptions or blocks in flowcharts should be understood as representing modules, segments, portions of code, or steps that include one or more instructions for implementing specific logical functions in the process, and alternate implementations are included within the scope of the present disclosure in which functions may be executed out of order from that shown or discussed, including substantially concurrently or in reverse order, depending on the functionality involved.

As is shown by operation **402**, part inconsistency **12** is scanned for with nondestructive inspection device **14**. Image **18** of part inconsistency **12** is communicated from nondestructive inspection device **14** to programmable device **16** (operation **404**). Image **18** of part inconsistency **12** is viewed with programmable device **16** (operation **406**). Image **18** of part inconsistency **12** is edited with programmable device **16** using input device **20** in communication with programmable device **16** (operation **408**). Edited image **18**A is communicated from programmable device **16** to laser projector **22** (operation **410**). Edited image **18**A is projected onto part inconsistency **12** using laser projector **22** (operation **412**).

FIG. **5**, an illustration of the projection of data from a scan of part inconsistency **12** being scanned with nondestructive inspection device **14**, is depicted in accordance with an illustrative embodiment. Part fragment **26** is shown being scanned in FIG. **5**, but part inconsistency **12** may be found in a preconstruction part or in a fully constructed machine or device.

FIG. **6** is an illustration of image **18** of part inconsistency **12** of FIG. **5** viewed using programmable device **16** in accordance with an illustrative embodiment. Programmable device **16** is connected to display device **24** for viewing image **18** and input device **20** for editing image **18**. Programmable device **16** shown in FIG. **6** is a personal computer, but could be a personal computer, laptop, personal digital assistant, or any other electronic device that can be used to view and edit image **18** received from nondestructive inspection device **14**. Programmable device **16** may include image editing software for editing image **18**.

FIG. **7** is an illustration of edited image **18**A of part inconsistency **12** of FIG. **6** viewed using programmable device **16** in accordance with an illustrative embodiment. The difference between image **18** shown in FIG. **6** and edited image **18**A shown in FIG. **7** is the inclusion of injection locations **28** edited onto image **18**. Injection locations **28** may identify locations on part inconsistency **12** where resin may be injected. While the rework referenced herein has been by resin injection, any rework that may be required to resolve a part inconsistency or other fault that may be identified with nondestructive inspection device **14** may be edited onto image **18** to form edited image **18**A.

FIG. **8** is an illustration of edited image **18**A of FIG. **7** projected onto part fragment **26** with laser projector **22** in accordance with an illustrative embodiment. Laser projector **22** may be any commercially available product that is capable of receiving edited image **18**A from programmable device **16** and reproducing edited image **18**A on part fragment **26** using emitted radiation **30**. Emitted radiation **30** should operate on a visible wavelength. Edited image **18**A projected onto part inconsistency **12** may include, as shown in the first exemplary embodiment, injection locations **28**. A technician may use projected injection locations **28** to identify where to make injections of resin or a similar substance. Edited image **18**A

may also include notes or details that identify the material to be injected, a depth at which to make the injection, a volume of material to be injected, and/or any other information that may be useful to a technician reworking part inconsistency **12**.

FIG. **9** is an illustration of the projection of data from a rescan of part inconsistency **12** of FIG. **8** being rescanned with nondestructive inspection device **14** in accordance with an illustrative embodiment. Once part inconsistency **12** is reworked, part inconsistency rework area **32** may be rescanned using nondestructive inspection device **14**. The second scan may be used to verify the rework to part inconsistency **12** was effective and part fragment **26** is usable. If the second scan shows the rework was insufficient to correct part inconsistency **12**, a second image produced by the second scan may be reviewed by the same or another programmable device. The second scan may be viewed with an overlay of edited image **18**A to determine why the first rework was insufficient and/or to identify a second rework respecting injection locations **28** of the first rework.

FIG. **10** is an illustration of second edited image **34** projected onto part fragment **26** of FIG. **9** with laser projector **22**, following the second scan, in accordance with an illustrative embodiment. Second edited image **34** may provide instruction to rework part inconsistency **12**. Second edited image **34** may also include injection locations **28** from the first rework to inform/remind the technicians of the work previously performed on part inconsistency **12**.

Image **18** may be scanned using recognizable and repeatable data points to allow edited image **18**A to be projected in substantially the same location. Image **18** may be scanned using aircraft coordinates or may be translated into aircraft coordinates after scanning. Injection locations **28** may be located using aircraft coordinates so that the rework is performed with precision. Image **18** may also be scanned using one or more reference points. The reference points may be retained within image **18** to allow the edited image to be projected in substantially the same location. The reference points may include a seam of an object.

In the illustrative example, second edited image **34** may also provide an ability to make a comparison of the original inconsistency with any remaining inconsistency that may be present after repair and another scan.

With reference to FIG. **11**, an illustration of a rework environment is depicted in the form of a block diagram in accordance with an illustrative embodiment. In this illustrative example, the different components and processes illustrated in FIGS. **1-10** above may be implemented in rework environment **1100** in the illustrative examples.

As depicted, rework environment **1100** includes rework system **1102**. Rework system **1102** may be used to process inconsistency **1104** for part **1106**. Part **1106** may be any suitable type of part. For example, part **1106** may be comprised of or include composite core structure **1108**, metal structure **1110**, or some other suitable type of structure. Composite core structure **1108** may include core **1112** located between facesheet **1114** and facesheet **1116**. In this illustrative example, metal structure **1110** may take the form of metal sheet **1118**.

As depicted, part **1106** may take various forms. For example, part **1106** may be a skin panel, a wing, a fuselage barrel, a door, a floor panel, a composite sheet, a wall, a stringer, or some other suitable type of part.

As depicted, rework system **1102** may be comprised of a number of different types of components. For example, nondestructive inspection system **1120**, rework generator **1122**, and projector system **1124** may be included in rework system **1102**.

In this illustrative example, nondestructive inspection system **1120** is a hardware system and may include one or more devices. A nondestructive inspection device in nondestructive inspection system **1120** may take various forms. For example, a nondestructive inspection device may be selected from one of an ultrasonic testing system, an eddy current testing system, an x-ray system, a magnetic resonance system, and a microwave testing system, or other suitable types of nondestructive inspection devices.

When more than one device is present in nondestructive inspection system **1120**, different types of nondestructive inspection devices may be present. For example, one device may be the camera and a second device may be an ultrasound inspection device.

In this illustrative example, nondestructive inspection system **1120** is configured to generate inspection information **1126**. Inspection information **1126** may include information about inconsistency **1104**. In this illustrative example, inspection information **1126** may include image **1128** of inconsistency **1104**.

When more than one device is present in nondestructive inspection system **1120**, different types of information may be present in inspection information **1126**. For example, a camera in nondestructive inspection system **1120** may generate visible light images and an ultrasound inspection device in nondestructive inspection system **1120** may generate images from sound signals.

In these illustrative examples, inconsistency **1104** may be located in at least one of surface **1130** or interior **1132** of part **1106** in location **1134** of part **1106**.

In addition to image **1128** of inconsistency **1104**, inspection information **1126** also may include coordinates **1136**. Coordinates **1136** may describe location **1134** as well as other information such as size **1138** of inconsistency **1104**. Size **1138** may be in two dimensions or three dimensions depending on the particular implementation.

In this illustrative example, nondestructive inspection system **1120** sends inspection information **1126** to rework generator **1122**. Rework generator **1122** is hardware and may include software.

Rework generator **1122** may be implemented in software, hardware, firmware or a combination thereof. When software is used, the operations performed by rework generator **1122** may be implemented in program code configured to run on a processor unit. When firmware is used, the operations performed by rework generator **1122** may be implemented in program code and data and stored in persistent memory to run on a processor unit. When hardware is employed, the hardware may include circuits that operate to perform the operations in rework generator **1122**.

In the illustrative examples, the hardware may take the form of a circuit system, an integrated circuit, an application specific integrated circuit (ASIC), a programmable logic device, or some other suitable type of hardware configured to perform a number of operations. With a programmable logic device, the device may be configured to perform the number of operations. The device may be reconfigured at a later time or may be permanently configured to perform the number of operations. Examples of programmable logic devices include, for example, a programmable logic array, a programmable array logic, a field programmable logic array, a field programmable gate array, and other suitable hardware devices. Additionally, the processes may be implemented in organic components integrated with inorganic components

and/or may be comprised entirely of organic components excluding a human being. For example, the processes may be implemented as circuits in organic semiconductors.

In this illustrative example, rework generator **1122** may be implemented in computer system **1140**. Computer system **1140** may include one or more computers. When more than one computer is present, those computers may be in communication with each other using a communications medium such as a network.

In this illustrative example, rework generator **1122** may be in a remote location to nondestructive inspection system **1120**. In other illustrative examples, these two components may be located in the same location.

Rework generator **1122** may place inconsistency **1104** into model **1141** of part **1106**. In the illustrative examples, model **1141** may be, for example, a computer-aided design model.

In this illustrative example, coordinates **1136** describing inconsistency **1104** in inspection information **1126** may be used to incorporate a representation of inconsistency **1104** into model **1141**. In this manner, model **1141** may be displayed on graphical user interface **1142** on display device **1143** in computer system **1140**. The display of model **1141** for part **1106** includes a display of inconsistency **1104** and part **1106**.

With this display, rework information **1144** may be generated. This rework information may be generated by operator **1145** interacting with rework generator **1122** through graphical user interface **1142**.

As depicted, rework generator **1122** generates rework information **1144** for use in performing rework on part **1106**. In this illustrative example, rework information **1144** may include at least one of group of images **1146**, instructions **1147**, or other suitable information.

As used herein, "a group of," when used with reference to items, means one or more items. For example, group of images **1146** is one or more images. Group of images **1146** may be used as template **1151** for performing rework. In this illustrative example, rework generator **1122** may be in a remote location to nondestructive inspection system **1120**. In other illustrative examples, these two components may be located in the same location.

In the illustrative examples, rework information **1144** may be used to process rework material **1148** to form patch **1150** for use in reworking part **1106** with respect to inconsistency **1104**. In particular, projector system **1124** may be used to project rework information **1144** for use in forming patch **1150**. In these illustrative examples, projector system **1124** is a hardware system and may include software. Projector system **1124** includes a group of projector devices configured to project images onto a surface. A projector device in projector system **1124** may be selected from one of a laser projector, a light emitting diode projector, a halogen light projector, an incandescent light projector and other suitable types of projector devices.

For example, image **1152** in group of images **1146** may be projected by projector system **1124** onto rework material **1148** as a pattern to generate patch **1150** from one or more pieces of rework material **1148**. In other words, image **1152** may define patch **1150** from rework material **1148**. The projection of image **1152** is performed under the control of rework generator **1122**, operator **1145**, or some other suitable controller. In this illustrative example, instructions **1147** may include instructions on generating patch **1150** in the illustrative example.

Additionally, projector system **1124** may project image **1154** from group of images **1146** onto surface **1130** of part **1106** under the control of rework generator **1122** in this illustrative example. Of course, in other illustrative examples, operator **1145** may control the projection of image **1154**. Image **1154** may be used as a template to perform rework on inconsistency **1104** in part **1106**. For example, image **1154** may be used as a template from which a portion of part **1106** may be removed. The portion may be removed to form, for example, a scarf, holes, or other features for performing the rework on part **1106**. Further, image **1152** may be also used to place patch **1150** onto part **1106**.

Image **1156** also may be projected onto part **1106** by projector system **1124** to verify whether the rework has been performed as desired. The projection of image **1156** may be performed under the control of rework generator **1122**, operator **1145**, or some other suitable controller. For example, image **1156** may be an image of inconsistency **1104**. The projection of image **1156** onto surface **1130** of part **1106** may be used to determine whether patch **1150** covers the area in which inconsistency **1104** was located prior to the rework being performed on part **1106**. In another illustrative example, image **1156** may be an outline of the patch in the desired location for the patch. In this manner, a determination may be made as to whether patch **1150** that has been installed has the desired dimensions and location.

The illustration of rework environment **1100** in FIG. **11** is not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some components may be unnecessary. Also, the blocks are presented to illustrate some functional components. One or more of these blocks may be combined, divided, or combined and divided into different blocks when implemented in an illustrative embodiment.

For example, inspection information **1126** may not include image **1128** in some illustrative examples. Instead, inspection information **1126** may include information that may be used to generate image **1128**. In this example, rework generator **1122** may be configured to generate image **1128** from inspection information **1126**.

As another illustrative example, inspection information **1126** may include one or more additional images in addition to image **1128**. As depicted, these images may be of different types depending on the type of nondestructive inspection devices that may be present in nondestructive inspection system **1120**. As another illustrative example, rework information **1144** may be generated by rework generator **1122** without input from operator **1145** in some illustrative examples. For example, rework generator **1122** may include a process that selects or designs patch **1150** for use in performing rework on part **1106**.

Turning now to FIGS. **12-17**, illustrations of a rework process for a composite core structure are depicted in accordance with illustrative embodiments. These figures illustrate one manner in which a rework may be identified and performed for a composite core structure. As depicted, the composite core structure may be a composite honeycomb core structure.

Turning to FIG. **12**, an illustration of an inspection of a part with a composite honeycomb core structure is depicted in accordance with an illustrative embodiment. In this illustrative example, part **1200** takes the form of honeycomb core structure **1202**. Honeycomb core structure **1202** is an example of an implementation for composite core structure **1108** in FIG. **11**. As depicted in this example, honeycomb core structure **1202** is comprised of first facesheet **1204** and second facesheet **1206** with honeycomb core **1208** located between first facesheet **1204** and second facesheet **1206**. In

this illustrative example, honeycomb core **1208** is shown in phantom under first facesheet **1204**.

In this illustrative example, honeycomb core structure **1202** has inconsistency **1210**. Inconsistency **1210** is identified using nondestructive inspection device **1212** in this particular example. The use of nondestructive inspection device **1212** to detect the presence of inconsistency **1210** may be considered part of a rework process.

As depicted, this device may be used to determine whether rework is needed for part **1200**. As depicted, nondestructive inspection device **1212** is an example of one implementation of a device that may be used in nondestructive inspection system **1120** in FIG. **11**.

As depicted, nondestructive inspection device **1212** may perform an ultrasonic inspection of honeycomb core structure **1202**. As depicted, nondestructive inspection device **1212** may generate inspection information about honeycomb core structure **1202** and inconsistency **1210**. In particular, the inspection information may include images of inconsistency **1210**.

Additionally, the inspection of part **1200** also may generate other inspection information. This inspection information may include, for example, coordinates for inconsistency **1210**. These coordinates describe inconsistency **1210**.

For example, the coordinates may describe the shape, size, location, orientation, and other suitable information about inconsistency **1210**. These coordinates may take the form of aircraft coordinates when part **1200** is located in an aircraft. Of course, any coordinate system may be used depending on the particular implementation.

In some illustrative examples, nondestructive inspection device **1212** also may be configured to project image **1214** of inconsistency **1210** onto surface **1216** of part **1200** in some illustrative examples. This projection of image **1214** may provide an operator a better visualization of inconsistency **1210** if inconsistency **1210** is located below surface **1216** of part **1200**.

Next, in FIG. **13**, an illustration of an inconsistency placed into a model of a part with a composite honeycomb core structure is depicted in accordance with an illustrative embodiment. In this illustrative example, rework generator **1300** is implemented in computer system **1302**. Rework generator **1300** displays model **1304** of part **1200** in FIG. **12** on display device **1306** in computer system **1302**.

As depicted, inconsistency **1210** is shown on model **1304** of part **1200** as graphical representation **1307**. In particular, coordinates describing inconsistency **1210** are integrated into model **1304**. The coordinates reflect the shape, size, location, and orientation of inconsistency **1210** in part **1200**. In this manner, inconsistency **1210** may be integrated into model **1304** and displayed on model **1304** on display device **1306**. In this illustrative example, rework information is identified.

Area **1308** defines the rework for honeycomb core structure **1202**. This area may be used to form a patch for reworking part **1200**.

As depicted, area **1308** is a circle around inconsistency **1210** shown on model **1304** on display device **1306**. In this illustrative example, area **1308** encompasses inconsistency **1210** as displayed on model **1304**.

In the illustrative example, rework generator **1300** creates an image of area **1308**. Also, rework generator **1300** identifies coordinates for area **1308**. In the illustrative examples, the coordinates may be coordinates for part **1200** or an object in which part **1200** is located. For example, if part **1200** is used on an aircraft, the coordinates may be aircraft coordinates for the aircraft.

The image of area **1308**, the coordinates, and instructions may be used to form rework information for performing rework on honeycomb core structure **1202**. With this rework information, a rework of part **1200** may be performed.

Turning now to FIG. **14**, an illustration of a projection of an image for reworking a composite honeycomb core structure is depicted in accordance with an illustrative embodiment. In this illustrative example, projector **1400** projects image **1402** onto surface **1216** of honeycomb core structure **1202**. As depicted, projector **1400** is an example of a device that may be used in projector system **1124** shown in block form in FIG. **11**. In this illustrative example, image **1402** includes circle **1403**.

The location of image **1402** on surface **1216** is based on coordinates identified for the image in model **1304** of part **1200**. Further, image **1402** may be sized based on the coordinates identified in the image of the model. The sizing of image **1402** is such that the image represents the rework area as accurately as desired with respect to dimensions and location of image **1402** when projected onto surface **1216** of part **1200**.

In this illustrative example, circle **1403** in image **1402** defines area **1308** in FIG. **13**. Circle **1403** defines area **1406** on surface **1216** for performing rework on part **1200**. Further, image **1402** also may include a display of inconsistency **1210**. In this illustrative example, the display of inconsistency **1210** takes the form of outline **1407**. This display may be especially useful when inconsistency **1210** is located below surface **1216** of part **1200**.

As can be seen, image **1214** is displayed in the appropriate location on surface **1216** of honeycomb core structure **1202** in part **1200** to perform the rework operations. In this manner, image **1214** may be used as a template or pattern to remove portions of honeycomb core structure **1202** in part **1200**. The template provided using image **1214** does not require contact or materials to be placed onto part **1200**. In other words, stencils, mylar sheets, and other physical components are not needed to perform the rework in this illustrative example.

With reference next to FIG. **15**, an illustration of a removal of a portion of a composite honeycomb core structure is depicted in accordance with an illustrative embodiment. In this illustration, portion **1500** of first facesheet **1204** of honeycomb core structure **1202** in part **1200** has been removed. Portion **1500** is removed based on the projection of image **1402**. Additionally, portion **1502** of honeycomb core **1208** is also removed in this illustrative example, leaving channel **1504**.

The cross-section for channel **1504** in honeycomb core structure **1202** is a circle corresponding to image **1214** as displayed on surface **1216** of honeycomb core structure **1202** by projector **1400** in FIG. **14**. Of course, in some cases, only portion **1500** of first facesheet **1204** may be removed depending on the extent of inconsistency **1210**.

Turning next to FIG. **16**, an illustration of the formation of a portion of a patch is depicted in accordance with an illustrative embodiment. In this illustrative example, projector **1600** projects image **1602** onto sheet of rework material **1604**. Image **1602** may be used as a template.

As depicted, portion **1606** is cut out of sheet of rework material **1604** based on the pattern in the template generated by image **1602** projected onto sheet of rework material **1604**. In this manner, stencils, contact paper, and physical templates may be avoided.

Portion **1606** forms a portion of a patch for reworking honeycomb core structure **1202**. In this example, portion **1606** is a replacement for portion **1500** removed from first facesheet **1204** in FIG. **15**.

With reference next to FIG. **17**, another illustration of the formation of a portion of a patch is depicted in accordance with an illustrative embodiment. As depicted, projector **1700** projects image **1702** onto honeycomb core material **1704**. With image **1702** as a template, portion **1706** of honeycomb core material **1704** in part **1200** is removed. Portion **1706** forms another part of a patch for use in reworking honeycomb core structure **1202**. As depicted, portion **1706** is a replacement for portion **1502** of honeycomb core **1208** removed from honeycomb core structure **1202** in FIG. **15**.

Turning next to FIG. **18**, an illustration of reworking a part with a honeycomb core structure is depicted in accordance with an illustrative embodiment. In this illustrative example, portion **1606** and portion **1706** form patch **1800** for use in performing rework on honeycomb core structure **1202** in part **1200**. As depicted, portion **1606** and portion **1706** for patch **1800** may be placed into channel **1504** bonded in with adhesive or other materials to other portions of honeycomb core structure **1202** for part **1200**.

With reference next to FIG. **19**, an illustration of a verification of rework on a honeycomb core structure is depicted in accordance with an illustrative embodiment. In this illustrative example, projector **1700** projects image **1702** onto surface **1216** of first facesheet **1204** of honeycomb core structure **1202** in part **1200**. As depicted, image **1702** includes circle **1403** for patch **1800** and outline **1407** of inconsistency **1210** from FIG. **11**.

In this illustrative example, image **1702** is displayed in the location in which the inconsistency **1210** was located prior to the rework being performed on honeycomb core structure **1202**. In this manner, a confirmation may be made as to whether patch **1800** was placed in the desired location. As a result, the rework of inconsistency **1210** may be inspected using image **1702** of inconsistency **1210** projected onto honeycomb core structure **1202**.

With reference next to FIGS. **20-25**, illustrations of a rework process for a metal structure are depicted in accordance with illustrative embodiments. These figures illustrate an example of one manner in which a rework may be performed for a metal structure.

Turning first to FIG. **20**, an illustration of inspection of a metal structure is depicted in accordance with an illustrative embodiment. In this depicted example, part **2000** includes metallic structure **2002** and inconsistency **2004**. Inconsistency **2004** takes the form of a crack in this particular example.

As depicted, nondestructive inspection device **2006** is used to perform an inspection of metallic structure **2002** for part **2000**. Nondestructive inspection device **2006** is another example of an implementation for a device that may be used in nondestructive inspection system **1120** in FIG. **11**. This inspection may be performed as part of an in-service inspection process when metallic structure **2002** is used in an aircraft.

In this illustrative example, nondestructive inspection device **2006** may be implemented in at least one of a current testing or ultrasonic testing to generate inspection information about part **2000** with inconsistency **2004**. Nondestructive inspection device **2006** is configured to generate one or more images of inconsistency **2004** in metallic structure **2002** in part **2000**.

Additionally, the inspection of part **2000** also may generate other inspection information. This inspection information may include, for example, coordinates for inconsistency **2004**. These coordinates describe inconsistency **2004** in metallic structure **2002**. For example, the coordinates may describe the shape, size, location, orientation, and other suitable information about inconsistency **2004**.

In some illustrative examples, image **2010** of inconsistency **2004** may be projected onto surface **2012** of metallic structure **2002** for part **2000**. Image **2010** may provide a better view of the location of inconsistency **2004** to an operator in the illustrative examples. Image **2010** may be especially useful if inconsistency **2004** is not visible to the operator.

Turning next to FIG. **21**, an illustration of an inconsistency placed into a model of a part is depicted in accordance with an illustrative embodiment. In this illustrative example, rework generator **2100** is implemented in computer system **2102**. As depicted, rework generator **2100** displays model **2104** of part **2000** from FIG. **21** on display device **2106** in computer system **2102**.

In this depicted example, inconsistency **2004** is shown as being displayed on model **2104** of part **2000** on display device **2106**. In particular, the display of inconsistency **2004** in the display of model **2104** is based on the coordinates of inconsistency **2004** identified during the inspection of metallic structure **2002**.

In this illustrative example, rework information may be identified using the display of inconsistency **2004** as displayed on model **2104** of part **2000**. As seen in this illustrative example, hole **2108** and hole **2110** are placed at the ends of inconsistency **2004**. Hole **2108** and hole **2110** are included as part of the rework of inconsistency **2004** to reduce the possibility that inconsistency **2004** may spread or become larger. These holes may be stop holes in some illustrative examples. Additionally, area **2112** is defined as an area in which rework is to be performed on part **2000**.

As depicted, hole **2108**, hole **2110**, and area **2112** may be used to form an image for performing rework. In particular, coordinates for these features may be included as part of the image for use in projecting the image onto part **2000**. In the illustrative examples, these coordinates may take the form of aircraft coordinates.

With reference now to FIG. **22**, an illustration of the creation of rework information is depicted in accordance with an illustrative embodiment. In this illustrative example, rework generator **2100** is configured to generate rework information such as graphical representation **2200** for a patch as displayed on model **2104** of part **2000**. In this illustrative example, area **2201** with holes **2202** may be a patch for placement over inconsistency **2004** on part **2000**. These holes may be used to install fasteners, such as bolts or other suitable types of fasteners.

In the illustrative examples, the rework information generated by rework generator **2100** may include images. These images may include, for example, an image of area **2112** with hole **2108** and hole **2110**. As another example, an image of graphical representation **2200** and holes **2202** in FIG. **22** also may be included as part of the rework information to create a patch for performing rework on part **2000**.

The rework information generated also may include instructions. These instructions may include instructions for forming the holes and for creating and installing the patch on part **2000**. In particular, the images may include an arrangement of holes for fasteners to secure a patch.

With reference now to FIG. **23**, an illustration of the formation of a patch is depicted in accordance with an illustrative embodiment. In this depicted example, projector **2300** projects image **2302** with graphical representation **2200** onto metal rework material **2304**. Image **2302** with graphical representation **2200** may be used as a template to form patch **2306** in this illustrative example.

Turning next to FIG. **24**, an illustration of reworking a metal structure is depicted in accordance with an illustrative embodiment. In this depicted example, projector **2400** projects image **2402** onto surface **2404** of metallic structure **2002** for part **2000**. As can be seen, image **2402** may be used as a template to form holes **2406** in metallic structure **2002** as part of the rework operation.

Turning now to FIG. **25**, another illustration of reworking a metal structure is depicted in accordance with an illustrative embodiment. In this illustrative example, patch **2306** is positioned over metallic structure **2002**. Additionally, fasteners **2500** may be used to fasten patch **2306** to metallic structure **2002** for part **2000** over inconsistency **2004**.

The illustrations of FIGS. **12-25** are not meant to limit the manner in which an illustrative embodiment may be implemented. For example, although the patches are shown as being circular in shape, the patch used to perform rework operations may have other shapes. For example, the patches may be square, rectangular, irregular in shape, or some other suitable shape. As another illustrative example, although a honeycomb core is shown in one example, other types of cores may be used. For example, a foam core, a wood core, or some other suitable type of core may be present in a core structure. In yet other illustrative examples, more than two facesheets may be present for a composite core structure.

With reference now to FIG. **26**, an illustration of a flowchart of a process for reworking an inconsistency on a part is depicted in accordance with an illustrative embodiment. The process illustrated in FIG. **26** may be implemented in rework environment **1100** in FIG. **11**. In particular, the process may be implemented in rework system **1102** in FIG. **11** in this illustrative example.

The process begins by inspecting a part to generate inspection information about the part (operation **2600**). This inspection information may include images and other suitable information. The inspection information may include, for example, coordinates of the location where the images were generated, a timestamp, and other suitable information. The inspection may be performed using nondestructive inspection system **1120** in FIG. **11**.

A determination is made as to whether an inconsistency is present from the inspection information generated from the inspection of the part (operation **2602**). If an inconsistency is identified from inspection information, the process identifies a location of an inconsistency on the part (operation **2604**). This location may be described using coordinates from the inspection information. The process then identifies a location of the inconsistency for the part in a model of the part (operation **2606**). The coordinates identified from the inspection information may be translated or transformed into the coordinates for the model of the parts.

The process then places the inconsistency into the model of the part (operation **2608**). In this operation, the inconsistency identified is included in the model for use in planning rework of the part.

Thereafter, the process generates an image for rework of the part with the inconsistency (operation **2610**). The image may be generated from inspection information about the inconsistency detected in the part. For example, this image may be generated based on the location of the inconsistency. An area encompassing the inconsistency may be identified for the rework of the inconsistency on the part in the location where the inconsistency is located based on the size of the inconsistency. In these illustrative examples, the area may be two-dimensional or three-dimensional depending on the particular implementation.

Thereafter, the image for the rework is projected on the surface of the part based on the location identified for the inconsistency in the model of the part (operation **2612**). In these illustrative examples, the image may form a template for performing rework.

Thereafter, the rework is performed for the inconsistency on the part using the image projected on the surface of the part (operation **2614**), with the process terminating thereafter.

With reference again operation **2602**, if an inconsistency is not identified in the inspection information, then rework of the part is unnecessary. The process terminates in this instance.

Turning now to FIG. **27**, an illustration of a flowchart of a process for performing rework on a composite core structure is depicted in accordance with an illustrative embodiment. The flowchart in FIG. **27** is an example of one manner in which operation **2614** may be performed for a composite core structure for a part such as a honeycomb core structure.

The process begins by removing a portion of at least one of a facesheet and a core from the honeycomb core structure based on the image projected onto the surface of the part (operation **2700**). In this manner, a portion of the facesheet, a portion of the core, or a portion of both may be removed as defined by the area shown in an image projected onto the surface of the honeycomb core structure for the part. For example, the area in the image may be a circle that may be used as a template to remove a portion of the honeycomb core structure. The area in the image may have other shapes such as an oval, a rectangle, a square, a triangle, a pentagon, an irregular shape, or other suitable shapes.

Thereafter, the process places a patch into the area where a portion of at least one of the facesheet and the core have been removed (operation **2702**), with the process terminating thereafter. The placement includes bonding or otherwise securing the patch to the honeycomb core structure.

With reference next to FIG. **28**, an illustration of a flowchart of a process for forming a patch for reworking a honeycomb core structure is depicted in accordance with an illustrative embodiment. The process illustrated in FIG. **28** may be used to generate a patch for use in operation **2614** in FIG. **26** and for the different operations in FIG. **27**.

The process begins by projecting an image for the patch onto rework material for a honeycomb core structure (operation **2800**). In this illustrative example, the rework material may be at least one of a facesheet, a honeycomb core, or other suitable types of material. The image projected onto the rework material has a shape for the patch to be performed. The image is projected onto the material such that, in addition to having the correct shape, the patch also has the correct size for use in performing the rework operation.

The process then cuts the rework material to form the patch (operation **2802**), with the process terminating thereafter. In this manner, an image may be used as a template to form a patch.

Turning now to FIG. **29**, an illustration of a flowchart of a process for performing rework on a metallic structure is depicted in accordance with an illustrative embodiment. The flowchart in FIG. **29** is an example of one manner in which operation **2614** may be performed for a metallic structure for a part.

The process begins by forming holes in a portion of at least one of the metallic structures based on the image projected onto the surface of the part (operation **2900**). These holes in the metallic structure may be configured to receive fasteners to connect the patch to the metallic structure. Additionally, the holes also may include holes that may be formed in the metallic structure used to reduce spreading of the inconsis-

tency in the part. In the illustrative examples, the image may be used as a template for identifying locations and sizes of the holes on the metallic structure.

Thereafter, the process places a patch onto the area where a portion of at least one of the facesheet and the core have been removed (operation **2902**). The process then connects the patch to the metallic structure (operation **2904**), with the process terminating thereafter. In operation **2904**, the patch may be secured in a number of ways. For example, fasteners, such as bolts, may be installed to secure the patch to the metallic structure. In another illustrative example, the patch may be welded, bonded, or otherwise secured to the metallic structure.

With reference next to FIG. **30**, an illustration of a flowchart of a process for creating a patch for a metallic structure is depicted in accordance with an illustrative embodiment. The process illustrated in FIG. **30** may be used to create a patch for use in operation **2614** in FIG. **26** and for the different operations in FIG. **29**.

The process begins by projecting an image onto rework material for forming a patch (operation **3000**). In this illustrative example, the image defines an area on the rework material to form a patch. In other words, the image may be used as a template to create a patch from the rework material. The process then cuts the rework material to form the patch (operation **3002**), with the process terminating thereafter.

The flowcharts and block diagrams in the different depicted embodiments illustrate the architecture, functionality, and operation of some possible implementations of apparatuses and methods in an illustrative embodiment. In this regard, each block in the flowcharts or block diagrams may represent a module, a segment, a function, and/or a portion of an operation or step. For example, one or more of the blocks may be implemented as program code, in hardware, or a combination of the program code and hardware. When implemented in hardware, the hardware may, for example, take the form of integrated circuits that are manufactured or configured to perform one or more operations in the flowcharts or block diagrams. When implemented as a combination of program code and hardware, the implementation may take the form of firmware.

In some alternative implementations of an illustrative embodiment, the function or functions noted in the blocks may occur out of the order noted in the figures. For example, in some cases, two blocks shown in succession may be executed substantially concurrently, or the blocks may sometimes be performed in the reverse order, depending upon the functionality involved. Also, other blocks may be added in addition to the illustrated blocks in a flowchart or block diagram.

For example, in addition to generating an image for rework of the part with the inconsistency in operation **2610**, other information also may be generated as part of operation **2610** for reworking the part. For example, instructions, diagrams, and other information also may be generated. This additional rework information also may be generated as a separate operation.

Turning now to FIG. **31**, an illustration of a block diagram of a data processing system is depicted in accordance with an illustrative embodiment. Data processing system **3100** may be used to implement programmable device **16** and computer system **1140**. In this illustrative example, data processing system **3100** includes communications framework **3102**, which provides communications between processor unit **3104**, memory **3106**, persistent storage **3108**, communications unit **3110**, input/output unit **3112**, and display **3114**. In this example, communication framework may take the form of a bus system.

Processor unit **3104** serves to execute instructions for software that may be loaded into memory **3106**. Processor unit **3104** may be a number of processors, a multi-processor core, or some other type of processor, depending on the particular implementation.

Memory **3106** and persistent storage **3108** are examples of storage devices **3116**. A storage device is any piece of hardware that is capable of storing information, such as, for example, without limitation, data, program code in functional form, and/or other suitable information either on a temporary basis and/or a permanent basis. Storage devices **3116** may also be referred to as computer readable storage devices in these illustrative examples. Memory **3106**, in these examples, may be, for example, a random access memory or any other suitable volatile or non-volatile storage device. Persistent storage **3108** may take various forms, depending on the particular implementation.

For example, persistent storage **3108** may contain one or more components or devices. For example, persistent storage **3108** may be a hard drive, a flash memory, a rewritable optical disk, a rewritable magnetic tape, or some combination of the above. The media used by persistent storage **3108** also may be removable. For example, a removable hard drive may be used for persistent storage **3108**.

Communications unit **3110**, in these illustrative examples, provides for communications with other data processing systems or devices. In these illustrative examples, communications unit **3110** is a network interface card.

Input/output unit **3112** allows for input and output of data with other devices that may be connected to data processing system **3100**. For example, input/output unit **3112** may provide a connection for user input through a keyboard, a mouse, and/or some other suitable input device. Further, input/output unit **3112** may send output to a printer. Display **3114** provides a mechanism to display information to a user.

Instructions for the operating system, applications, and/or programs may be located in storage devices **3116**, which are in communication with processor unit **3104** through communications framework **3102**. The processes of the different embodiments may be performed by processor unit **3104** using computer-implemented instructions, which may be located in a memory, such as memory **3106**.

These instructions are referred to as program code, computer usable program code, or computer readable program code that may be read and executed by a processor in processor unit **3104**. The program code in the different embodiments may be embodied on different physical or computer readable storage media, such as memory **3106** or persistent storage **3108**.

Program code **3118** is located in a functional form on computer readable media **3120** that is selectively removable and may be loaded onto or transferred to data processing system **3100** for execution by processor unit **3104**. Program code **3118** and computer readable media **3120** form computer program product **3122** in these illustrative examples. In one example, computer readable media **3120** may be computer readable storage media **3124** or computer readable signal media **3126**.

In these illustrative examples, computer readable storage media **3124** is a physical or tangible storage device used to store program code **3118** rather than a medium that propagates or transmits program code **3118**.

Alternatively, program code **3118** may be transferred to data processing system **3100** using computer readable signal

media **3126**. Computer readable signal media **3126** may be, for example, a propagated data signal containing program code **3118**. For example, computer readable signal media **3126** may be an electromagnetic signal, an optical signal, and/or any other suitable type of signal. These signals may be transmitted over communications links, such as wireless communications links, optical fiber cable, coaxial cable, a wire, and/or any other suitable type of communications link.

The different components illustrated for data processing system **3100** are not meant to provide architectural limitations to the manner in which different embodiments may be implemented. The different illustrative embodiments may be implemented in a data processing system including components in addition to and/or in place of those illustrated for data processing system **3100**. Other components shown in FIG. **31** can be varied from the illustrative examples shown. The different embodiments may be implemented using any hardware device or system capable of running program code **3118**.

In this manner, one or more illustrative embodiments may use digital data such as images to provide guides to operators in performing rework on different parts. In this manner, non-contact marking may be used to locate areas for which rework is to be performed. One or more illustrative examples may be used to avoid the need for paper, mylar transfers, or other currently used techniques that may be more time-consuming and difficult than use than desired.

The illustration of the different illustrative embodiments has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. Further, different illustrative embodiments may provide different features as compared to other illustrative embodiments. The embodiment or embodiments selected are chosen and described in order to best explain the principles of the embodiments, the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

1. A method for reworking an inconsistency on a part, the method comprising:

identifying a location of the inconsistency for the part in a model of the part;

generating an image for a rework for the part, wherein the image comprises an arrangement of holes for fasteners to secure a patch;

projecting the image for the rework on the part based on the location identified for the inconsistency; and

performing the rework for the inconsistency on the part using the image projected on the part.

2. The method of claim **1** comprising:

generating inspection information about the part with the inconsistency and wherein generating the image for the rework of the inconsistency comprises:

generating the image for the rework of the part from the inspection information about the part with the inconsistency.

3. The method of claim **1**, wherein the part is selected from one of a composite core structure, a composite honeycomb core structure, a composite sheet, and a metal sheet.

4. The method of claim **1**, wherein the image comprises an area of the part for removal.

5. The method of claim **1**, wherein the part is a honeycomb core structure and performing the rework comprises:

removing a portion of at least one of a facesheet and a core from the honeycomb core structure.

6. The method of claim **1** further comprising:

inspecting the rework for the inconsistency on the part using the image of the inconsistency projected on the part.

7. The method of claim **1**, wherein the image is a first image and further comprising:

projecting a second image onto rework material; and

forming a patch from the rework material using the second image.

8. The method of claim **1**, wherein the image is projected on the part by a projector system.

9. The method of claim **8**, wherein the projector system is comprised of a group of projector devices, wherein a projector device in the group of projector devices is selected from one of a laser projector, a light emitting diode projector, a halogen light projector, and an incandescent light projector.

10. The method of claim **2**, wherein the inspection information is generated using a nondestructive inspection system.

11. An apparatus comprising:

a rework generator configured to identify a location of an inconsistency for a part in a model of the part; generate an image for a rework for the part, wherein the image comprises an arrangement of holes for fasteners to secure a patch; project the image for the rework on the part based on the location identified for the inconsistency; and perform the rework for the inconsistency on the part using the image projected on the part.

12. The apparatus of claim **11** further comprising:

a projector system configured to project the image for the rework on the part under control of the rework generator.

13. The apparatus of claim **11** further comprising:

a nondestructive inspection system configured to generate inspection information about the part with the inconsistency and wherein the rework generator is configured to generate the image for the rework of the part from the inspection information.

14. The apparatus of claim **11**, wherein the part is selected from one of a composite core structure, a composite honeycomb core structure, a composite sheet, and a metal sheet.

15. The apparatus of claim **11**, wherein the image comprises an area of the part for removal.

16. The apparatus of claim **11**, wherein the part is a honeycomb core structure and performing the rework comprises removal of a portion of at least one of a facesheet and a core from the honeycomb core structure.

17. The apparatus of claim **11**, wherein the image is a first image and wherein the rework generator is further configured to project a second image onto rework material defining a patch from the rework material using the second image.

18. The apparatus of claim **12**, wherein the projector system is comprised of a group of projector devices, wherein a projector device in the group of projector devices is selected from one of a laser projector, a light emitting diode projector, a halogen light projector, and an incandescent light projector.

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